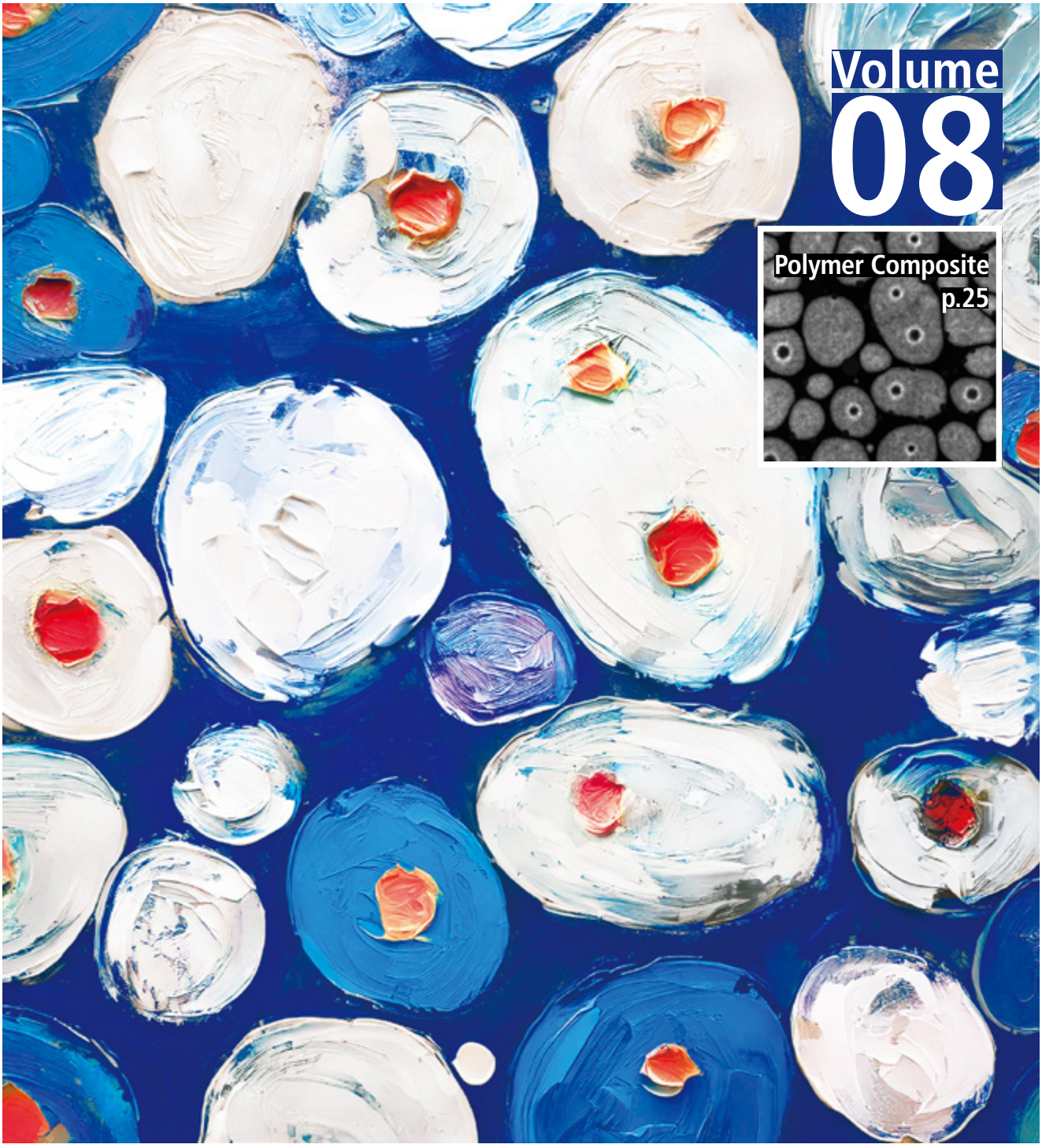
Enabling Nanoscale Advances

Park SYSTEMS

NANOSCALE IMAGE GALLERY

Elevate nanoscale exploration with Atomic Force Microscopy and advanced nanometrology



NANOSCALE IMAGE GALLERY

Explore an extensive collection of nanoscale measurement images obtained using advanced Atomic Force Microscopy (AFM) and nanometrology systems by Park Systems. This gallery showcases high-resolution imaging across diverse applications, from materials science and semiconductor analysis to biological imaging, achieved through various AFM modes, including non-contact, tapping, and conductive AFM. Each image highlights the precision, versatility, and advanced capabilities of Park Systems' technologies in capturing intricate surface details, structural characteristics, and nanoscale properties of a wide array of sample types, from micro-LEDs to biomolecules.

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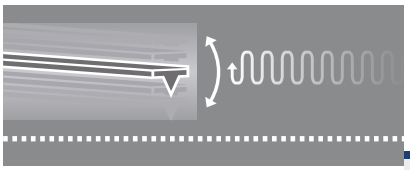
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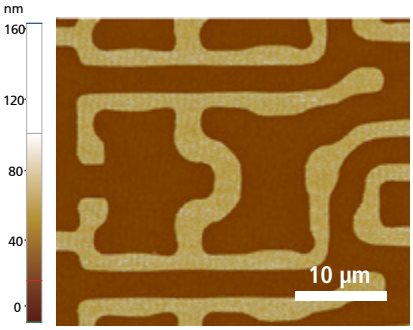
Display Backplane (LTPS TFT)



Non-contact

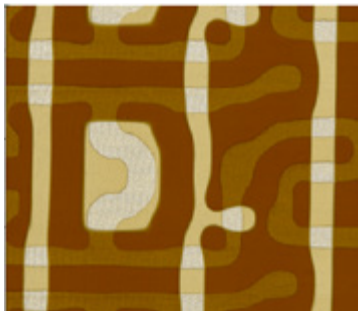
Height Images of

Active Layer



Peak to valley: 175.6 nm

Gate Pattern 1



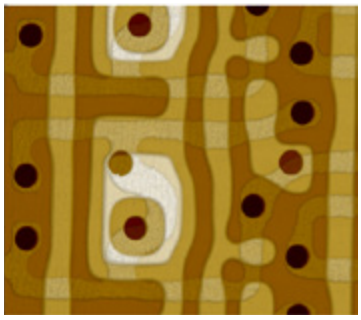
Peak to valley: 446.4 nm

Gate Pattern 2



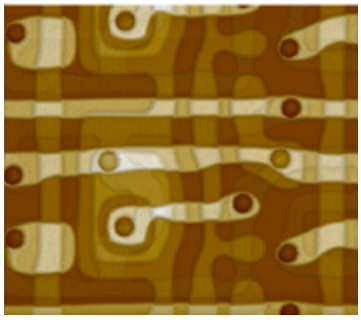
Peak to valley: 685.5 nm

Contact Hole



Peak to valley: 1329 nm

Source/Drain



Peak to valley: 1984 nm

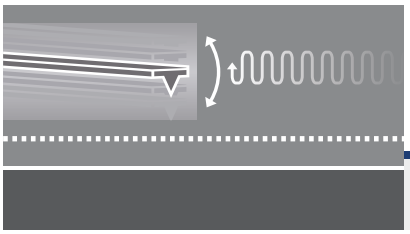
- LTPS (Low-Temperature Polycrystalline Silicon) TFT (Thin-Film Transistor) backplane is the advanced foundation of a display that supports superior resolution, better performance, and energy efficiency.

  It is critical in OLED or LCD screens, where it acts as the "brains" of the display, coordinating which pixels light up and how brightly.

Scanning conditions

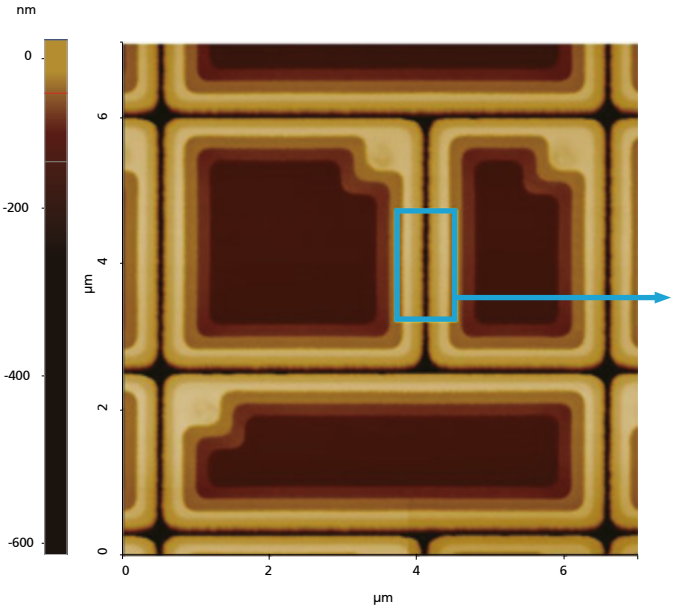
- System: NX-TSH
- Scan Size: All 40 µm × 35 µm
- Scan Mode: Non-contact
- Scan Rate: All 0.1 Hz
- Cantilever: AC160TS (k=26 N/m, f=300 kHz)
- Pixel Size: All 1024 × 1024

RGB Cells Black Matrix



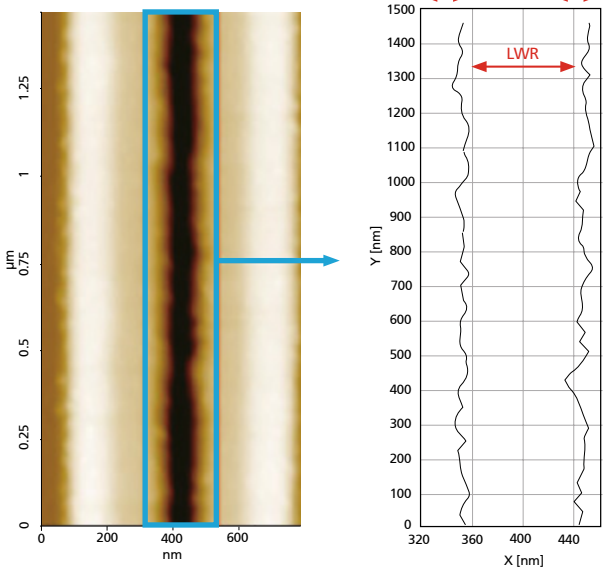
Non-contact

Height



Peak to valley: 630 nm

Cropped Height

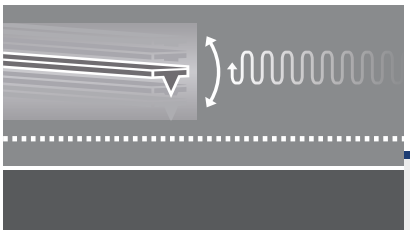


- Edge Profile
  - LER_L: Line Edge Roughness of Left sidewall
  - LER_R: Line Edge Roughness of Right sidewall
  - LWR: Line Width Roughness

Scanning conditions

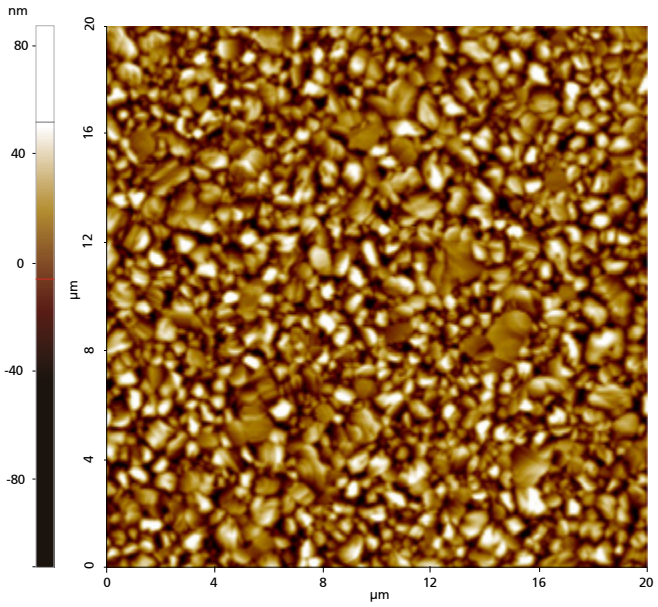
- System: NX-Wafer
- Scan Size: 7 µm × 7 µm, 0.8 µm × 1.5 µm
- Scan Mode: Non-contact
- Scan Rate: All 5 Hz
- Cantilever: EBD4-200A (k=40 N/m, f=320 kHz)
- Pixel Size: 1024 × 512, 117 × 110

Tandem Solar Cell



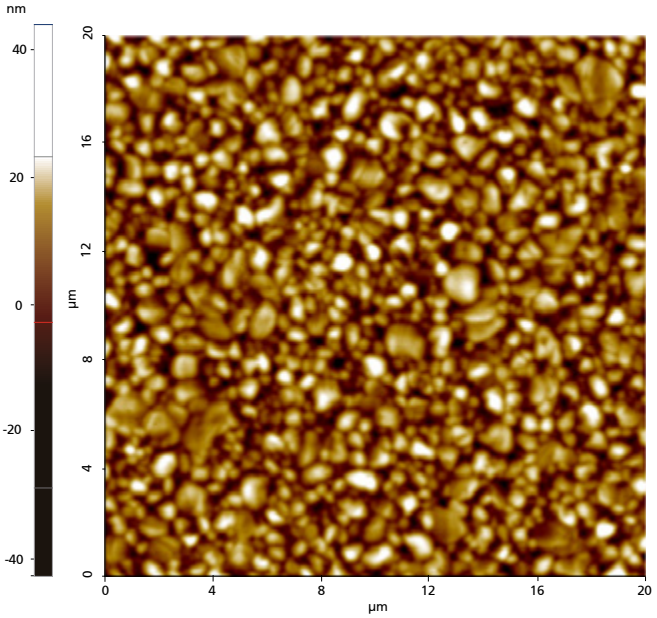
Non-contact

Height of Partially finished solar cell



Peak to valley: 199 nm

Height of Finished solar cell



Peak to valley: 84.8 nm

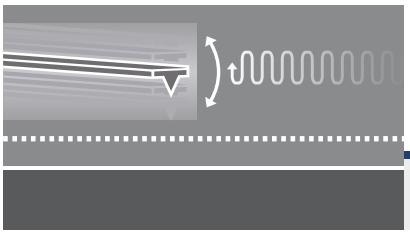
- A tandem solar cell consists of multiple layers of different photovoltaic materials stacked on top of each other to improve efficiency.

  While controlled roughness enhances light absorption and efficiency, excessive roughness can lead to defects, increased recombination, and reduced stability.

Scanning conditions

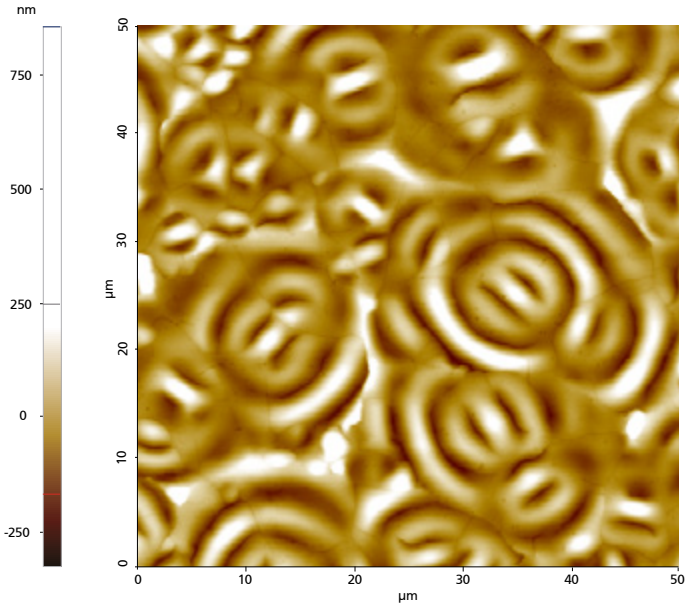
- System: FX200
- Scan Size: All 20 µm × 20 µm
- Scan Mode: Non-contact
- Scan Rate: All 0.8 Hz
- Cantilever: AC160TS (k=26 N/m, f=300 kHz)
- Pixel Size: All 512 × 256

FTO Glass



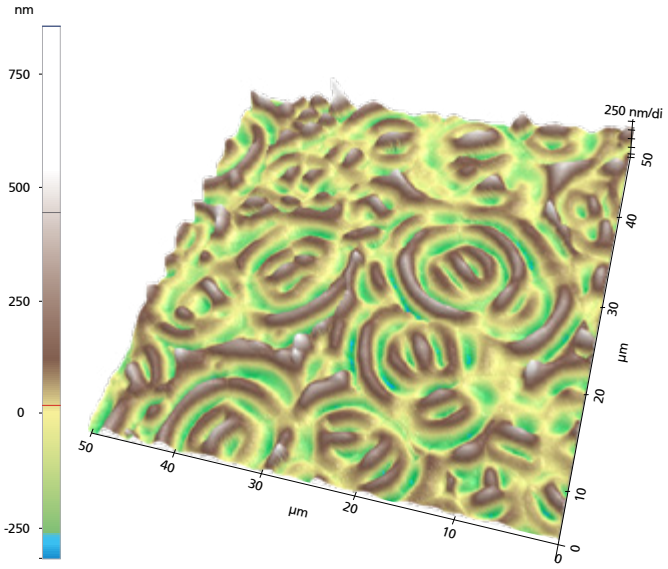
Non-contact

Height



Peak to valley: 1.2 µm

3D Image



X:Y:Z scale = 1:1:5

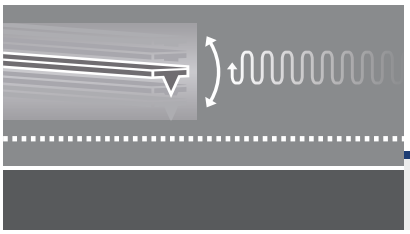
- Fluorine-doped tin oxide (FTO) glass is a transparent conductive material used in applications such as solar cells, touchscreens, and energy-efficient windows.

  The surface morphology of FTO glass is a critical factor as it influences thin-film coatings (e.g., solar cells, OLEDs) or the adjustment of optical properties such as transmittance and reflectance.

Scanning conditions

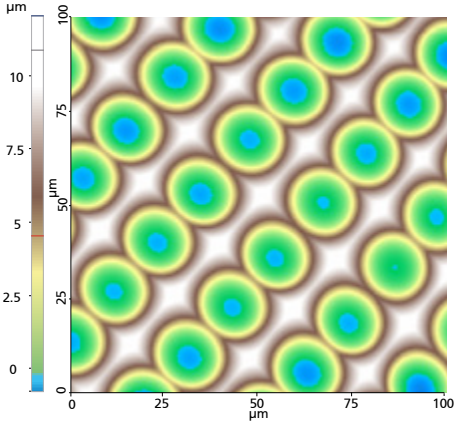
- System: FX200
- Scan Size: 50 µm × 50 µm
- Scan Mode: Non-contact
- Scan Rate: 0.3 Hz
- Cantilever: SCOUT 350 (k=42 N/m, f=350 kHz)
- Pixel Size: 512 × 512

Microlens Array



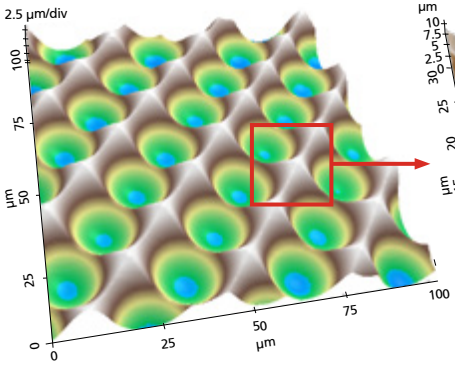
Non-contact

Height



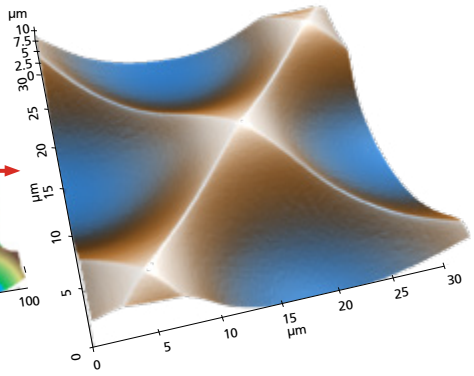
Peak to valley: 12.7 µm

3D Image



X:Y:Z scale = 1:1:1

Zoom-in 3D Image

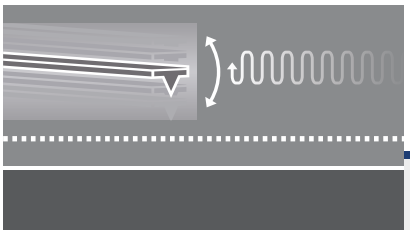


X:Y:Z scale = 1:1:0.5

Scanning conditions

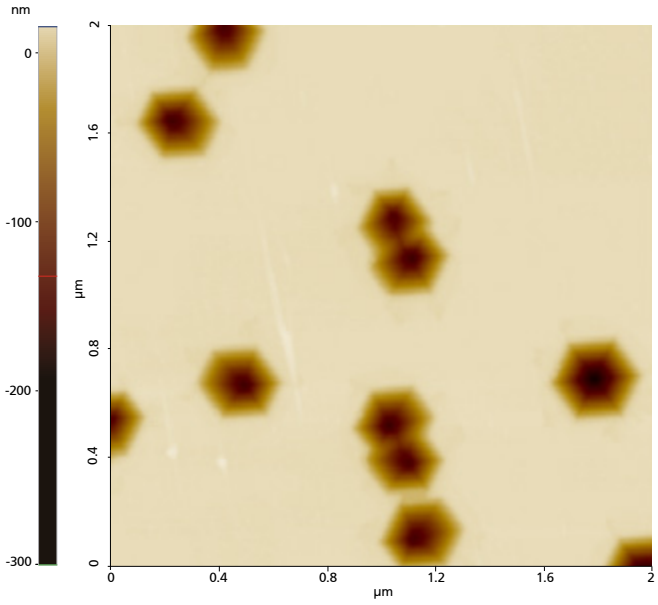
- System: FX200
- Scan Size: 100 µm × 100 µm, 30 µm × 30 µm
- Scan Mode: Non-contact
- Scan Rate: All 0.2 Hz
- Cantilever: AC160TS (k=26 N/m, f=300 kHz)
- Pixel Size: All 512 × 256

GaN epi Defect on Sapphire Substrate

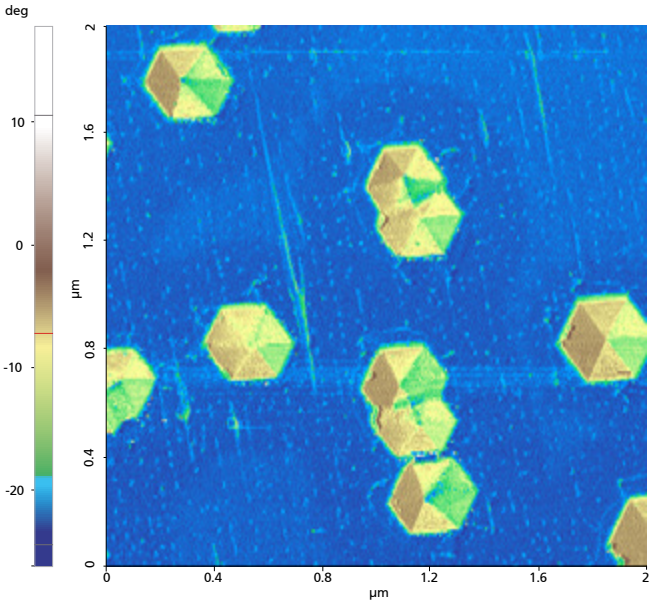


Non-contact

Height



Phase



Peak to valley: 315 nm

- When GaN is grown on a Sapphire substrate, the difference in lattice constants between the substrate and GaN will lead to the formation of defects in the epitaxial layer.

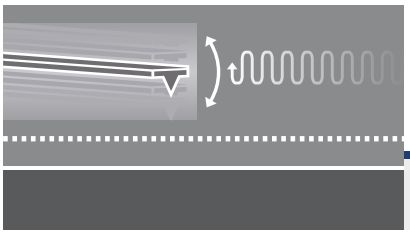
  This stress will be released by generating defects such as dislocations to achieve energy balance.

• Sample courtesy: Fudan University

Scanning conditions

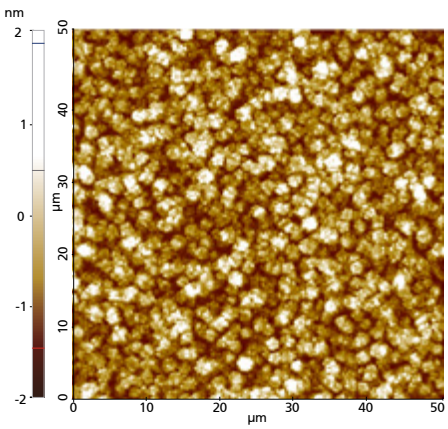
- System: NX20
- Scan Size: 2 µm × 2 µm
- Scan Mode: Non-contact
- Scan Rate: 0.5 Hz
- Cantilever: AC240TS (k=2 N/m, f=70 kHz)
- Pixel Size: 512 × 256

Electrodeposited Copper Foil for Flexible PCB



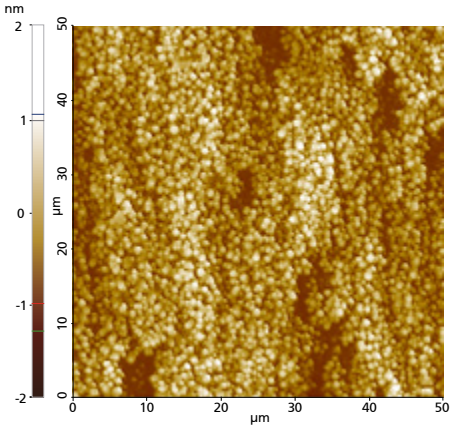
Non-contact

Height of Process 1



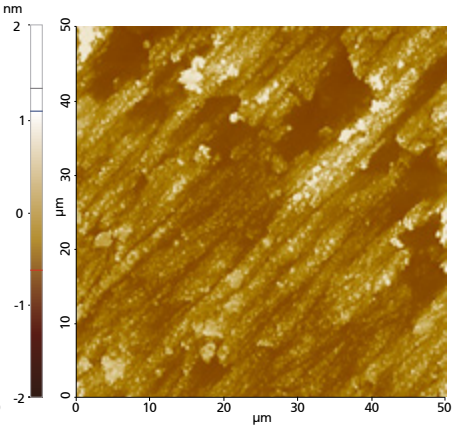
Peak to valley: 4.05 nm

Height of Process 2



Peak to valley: 2.31 nm

Height of Process 3



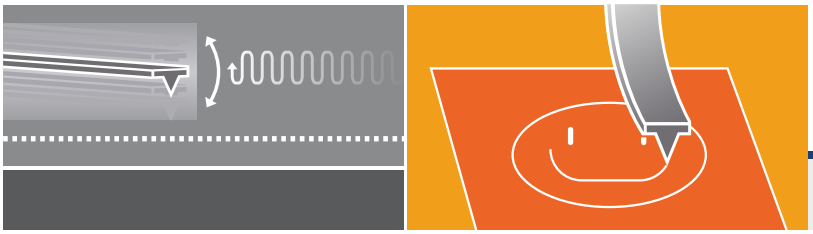
Peak to valley: 1.75 nm

- Higher surface roughness improves adhesion to dielectric layers but may affect signal transmission at high frequencies. A columnar grain structure impacts its flexibility and crack resistance.

Scanning conditions

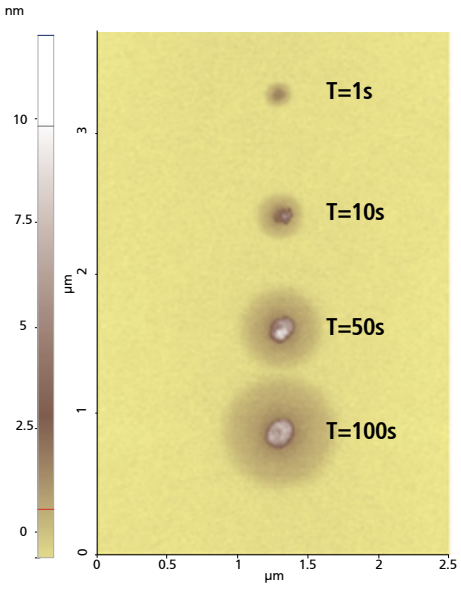
- System: FX200
- Scan Size: All 50 µm × 50 µm
- Scan Mode: Non-contact
- Scan Rate: All 1 Hz
- Cantilever: AC160TS (k=26 N/m, f=300 kHz)
- Pixel Size: All 512 × 512

Nanodots on Si



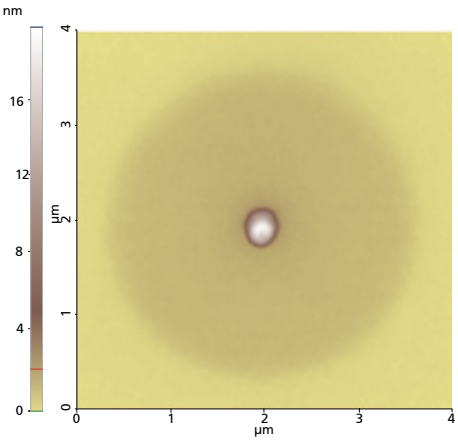
Non-contact, Nanolithography

Height of 'T=1~100s'



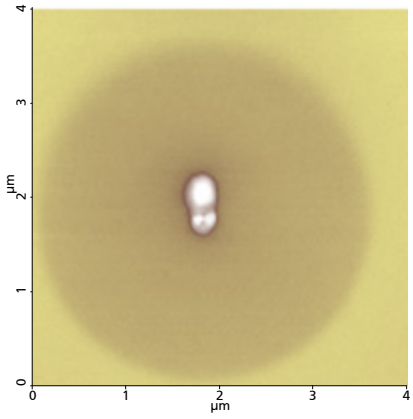
Peak to valley: 12.77 nm

Height of 'T=1000s'



Peak to valley: 20.05 nm

Height of 'T=2000s'



Peak to valley: 20 nm

- Nanodot height depends on dwell time, bias, and humidity, reaching saturation at around 20 nm.

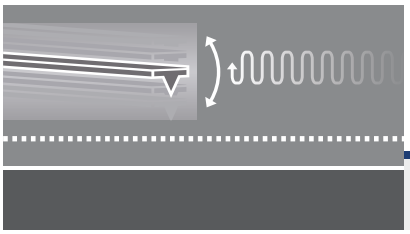
- Nanodots on a disc-shaped structure were formed using anodic oxidation lithography on Silicon with dwell times from 1s to 2000s. Disc oxide forms from lateral diffusion of oxyanions in the water meniscus, while nanodot oxide forms due to current from oxyanion migration to the p-doped silicon surface under bias. Longer dwell times increase water meniscus size, ion diffusion, and disc radius.

• Sample courtesy: Sanket Jugade, Prof. Akshay Naik, Centre for Nano Science and Engineering, Indian Institute of Science Bengaluru, India

Scanning conditions

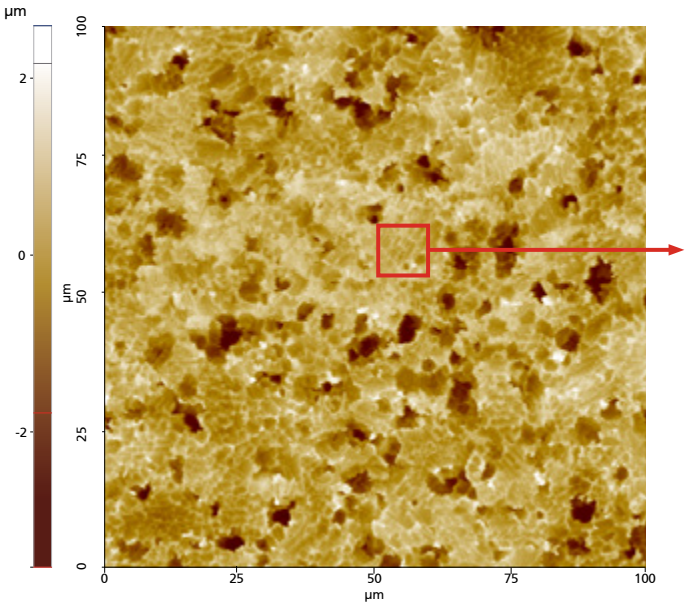
- System: NX20
- Scan Size: 2.5 µm × 4 µm, 4 µm × 4 µm
- Scan Mode: Non-contact after Litho
- Scan Rate: 1 Hz, 0.8 Hz
- Cantilever: ElectriMulti75-G (k=3 N/m, f=75 kHz)
- Pixel Size: All 256 × 256

Chemical Etched Titanium Disc



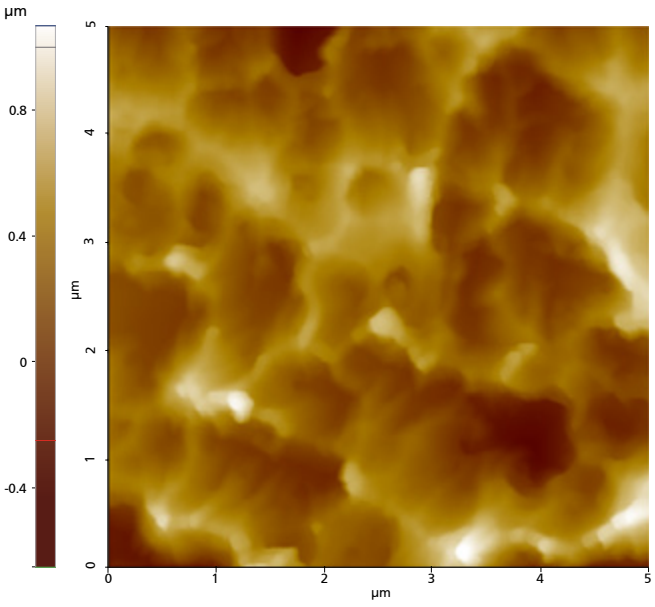
Non-contact

Height



Peak to valley: 6.1 µm

Zoom-in Height



Peak to valley: 1.7 µm

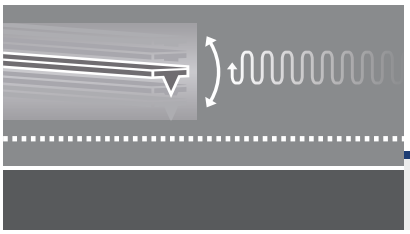
- Chemically etched titanium discs are widely utilized in biomedical applications, particularly in dental and orthopedic implants, where the controlled surface roughness facilitates enhanced osseointegration by promoting cellular adhesion and bone tissue integration.

  They also improve coating adhesion and frictional properties in electronic and aerospace applications.

Scanning conditions

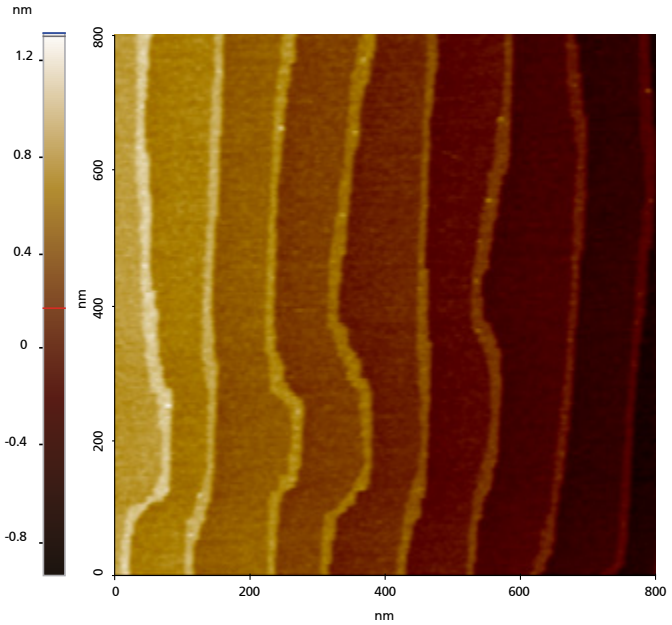
- System: FX200
- Scan Size: 100 µm × 100 µm, 5 µm × 5 µm
- Scan Mode: Non-contact
- Scan Rate: 0.2 Hz, 0.8 Hz
- Cantilever: PPP-NCHR (k=42 N/m, f=320 kHz)
- Pixel Size: 1024 × 512, 512 × 256

STO (110)



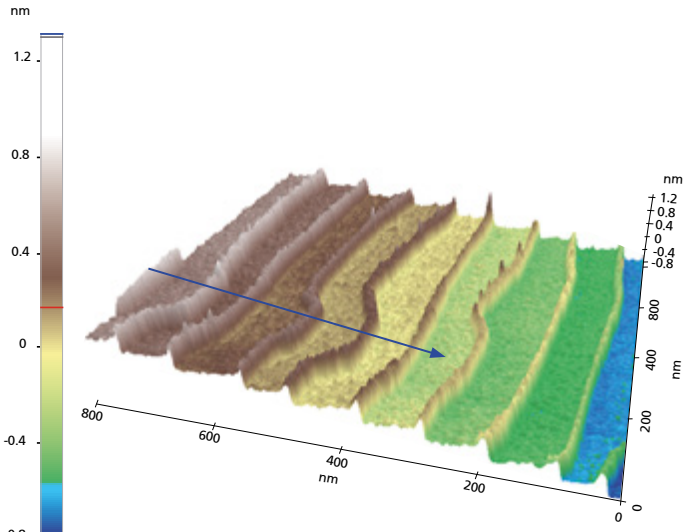
Non-contact

Height



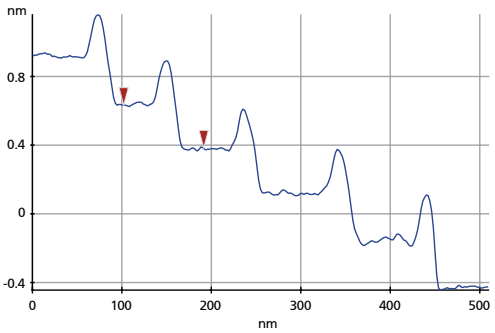
Peak to valley: 2.25 nm

3D Image



X:Y:Z scale = 1:1:70

Line profile

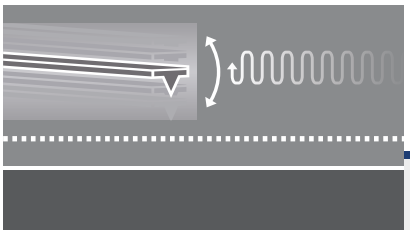


Cursor	ΔY(nm)
Red	-0.265

Scanning conditions

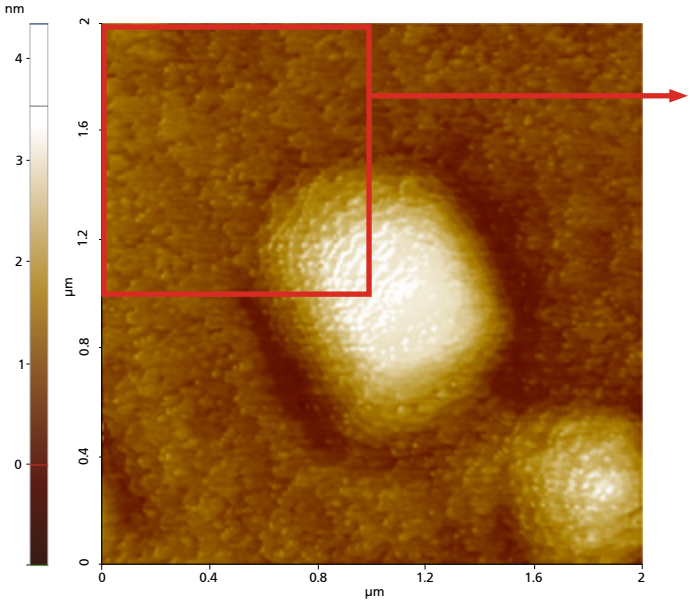
- System: FX200
- Scan Size: 800 nm × 800 nm
- Scan Mode: Non-contact
- Scan Rate: 0.6 Hz
- Cantilever: SCOUT 350 (k=42 N/m, f=350 kHz)
- Pixel Size: 512 × 256

InAs Quantum Dots Embedded on a GaSb Substrate



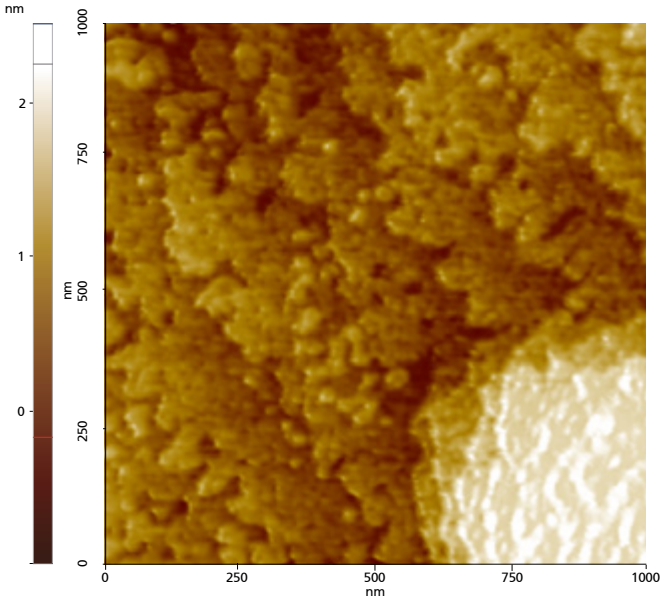
Non-contact

Height



Peak to valley: 5.3 nm

Zoom-in Height



Peak to valley: 3.5 nm

- InAs quantum dots on a GaSb substrate present a promising material system for infrared photonics due to their Type-II band alignment, tunable optical properties, and long carrier lifetimes.

  Precise tuning of dot size and density is crucial for optimizing emission properties.

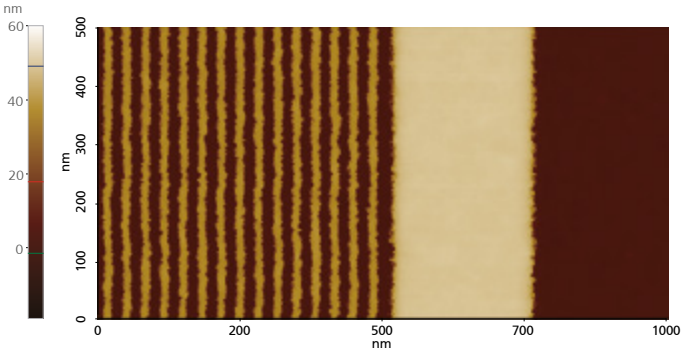
Scanning conditions

- System: NX7
- Scan Size: 2 µm × 2 µm, 1 µm × 1 µm
- Scan Mode: Non-contact
- Scan Rate: All 1 Hz
- Cantilever: AC160TS (k=26 N/m, f=300 kHz)
- Pixel Size: All 256 × 256

Post TiN Etch

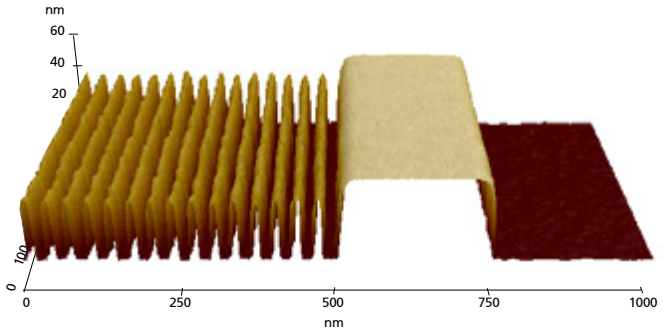
Narrow Trench Mode

Height



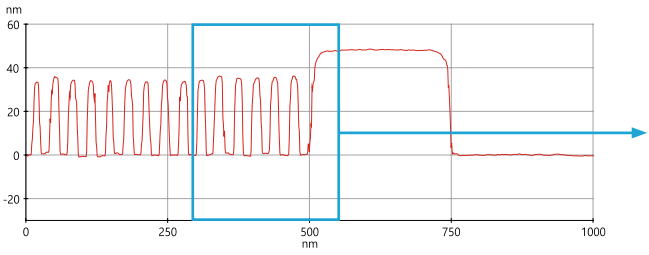
Peak to valley: 50.4 nm

3D Image

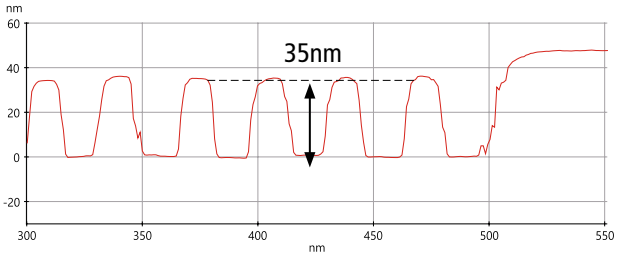


X:Y:Z scale = 1:1:3

Line profile



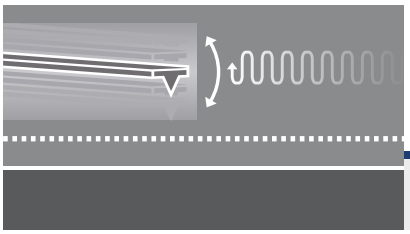
Zoom-in Line profile (Isotropic scale)



Scanning conditions

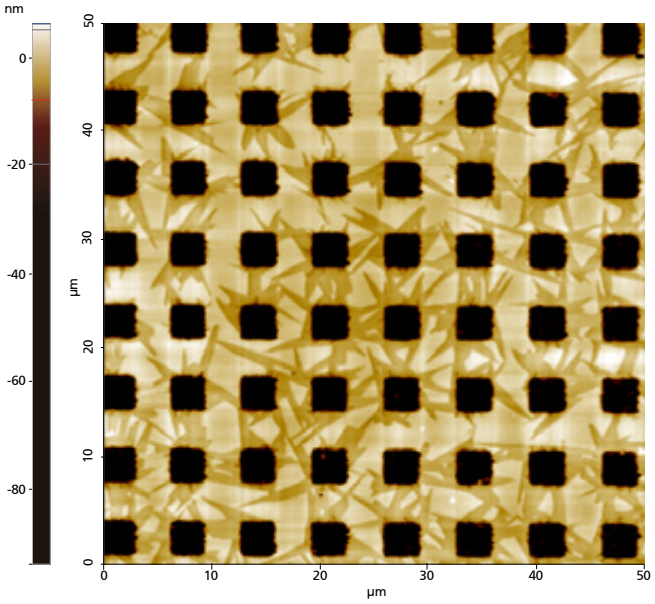
- System: NX-Wafer
- Scan Size: 1 µm × 0.5 µm
- Scan Mode: Narrow Trench Mode
- Scan Rate: 0.05 Hz
- Cantilever: MSS-Soft (k=2.8 N/m, f=75 kHz)
- Pixel Size: 1024 × 256

Cu Pad



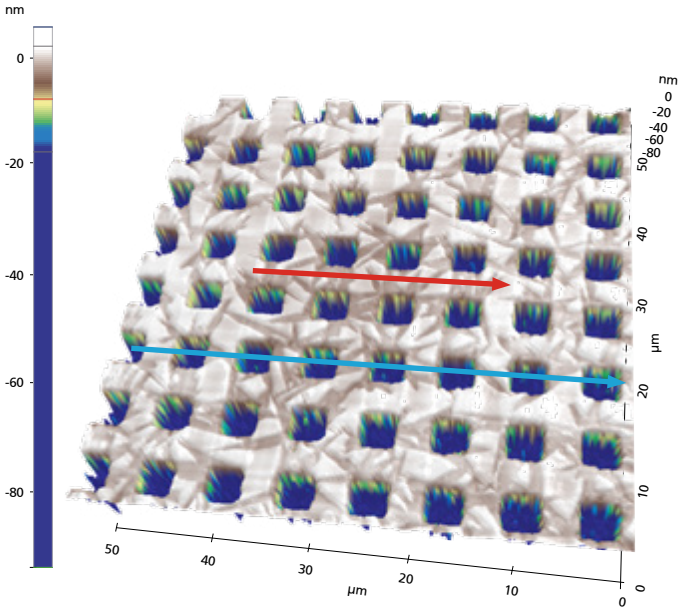
Non-contact

Height



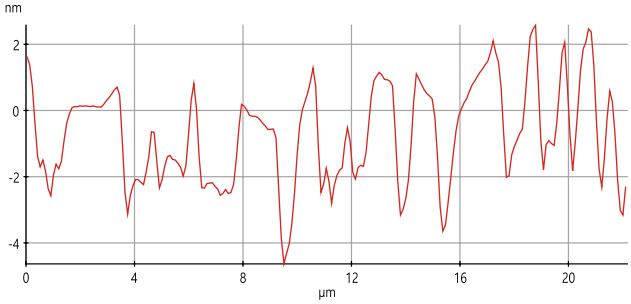
Peak to valley: 99 nm

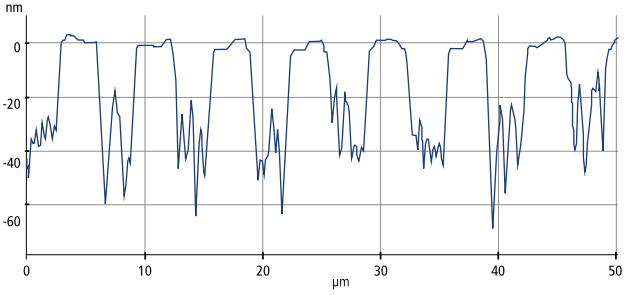
3D Image



X:Y:Z scale = 1:1:100

Line Profile

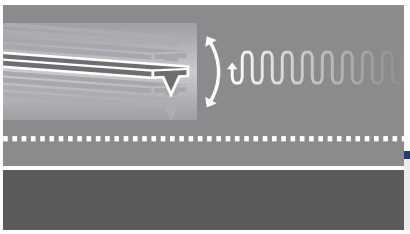




Scanning conditions

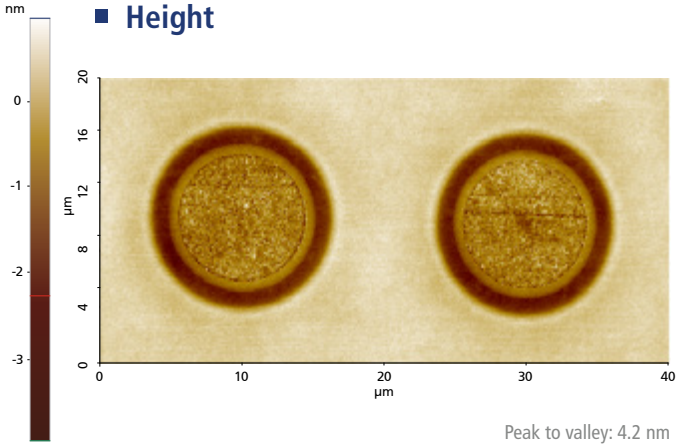
- System: FX200
- Scan Size: 50 µm × 50 µm
- Scan Mode: Non-contact
- Scan Rate: 0.2 Hz
- Cantilever: SCOUT 350 (k=42 N/m, f=350 kHz)
- Pixel Size: 512 × 512

Cu Pad (Dishing Analysis)



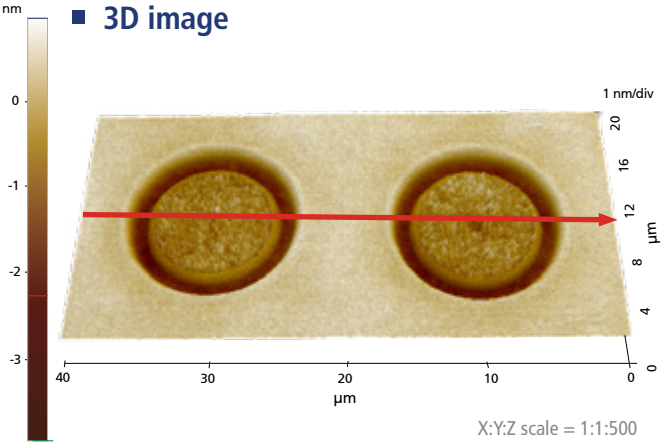
Non-contact

Height



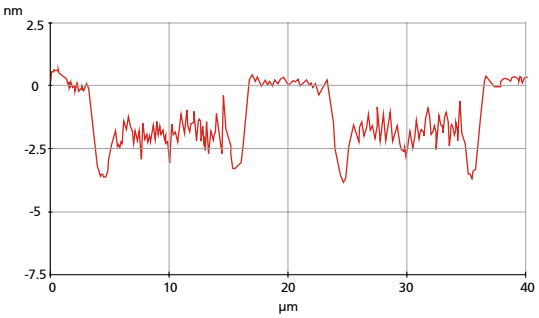
Peak to valley: 4.2 nm

3D image



X:Y:Z scale = 1:1:500

Line profile



- Cu pad dishing analysis is the study of how the amount of dishing in copper pads changes during the chemical mechanical polishing (CMP) process.

  It helps to ensure reliable interconnections between chips and to improve the quality of hybrid bonding.

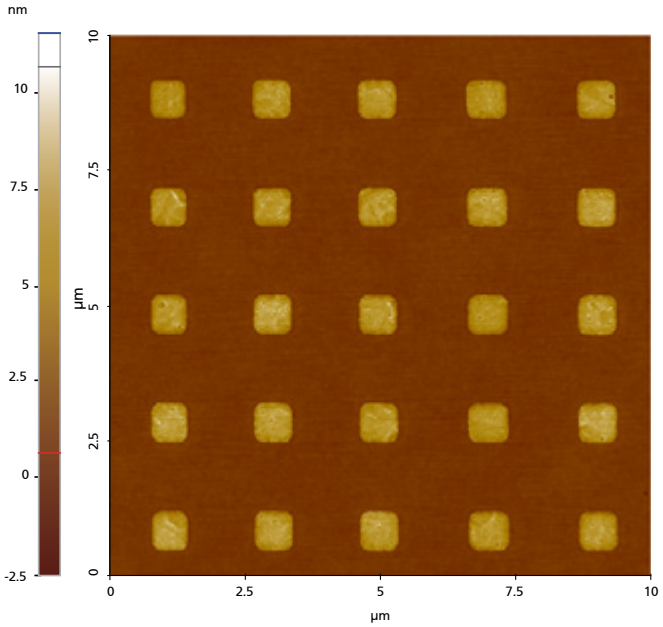
Scanning conditions

- System: NX-Wafer
- Scan Size: 40 µm × 20 µm
- Scan Mode: Non-contact
- Scan Rate: 0.2 Hz
- Cantilever: AD-40-AS (k=40 N/m, f=200 kHz)
- Pixel Size: 512 × 256

Cu Pad (Type 1)

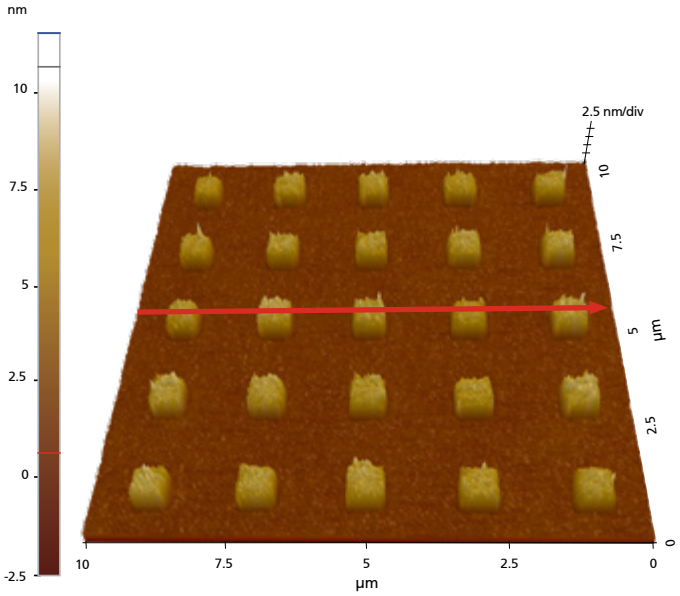
FiCM

Height



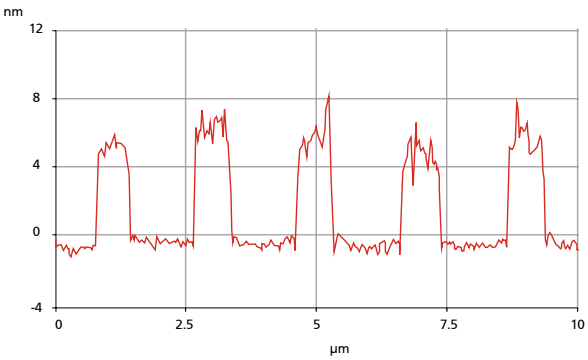
Peak to valley: 14.71 nm

3D Image



X:Y:Z scale = 1:1:100

Line profile



- Array type: Rectangle
  Pad shape: Rectangle
  Pad size: 0.75 µm
  Pitch: 2 µm

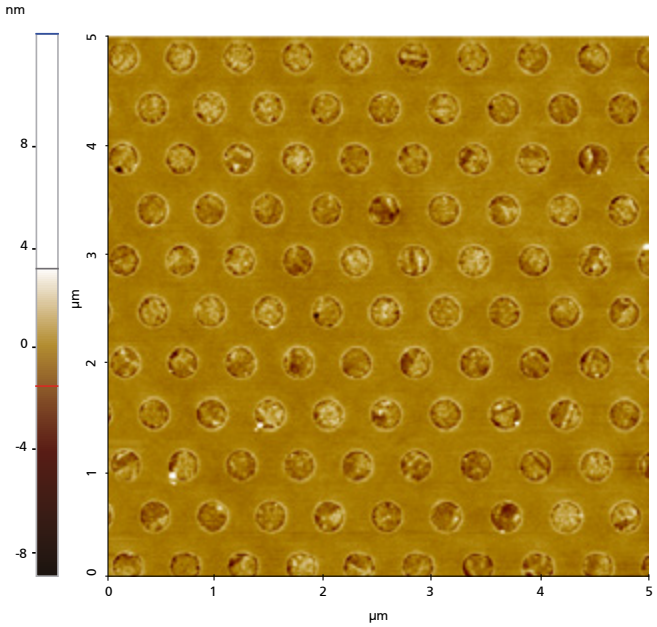
Scanning conditions

- System: NX-Wafer
- Scan Size: 10 µm × 10 µm
- Scan Mode: FiCM
- Scan Rate: 20 Hz
- Cantilever: biosphere B50-CONT (k=0.2 N/m, f=13 kHz)
- Pixel Size: 512 × 512

Cu Pad (Type 2)

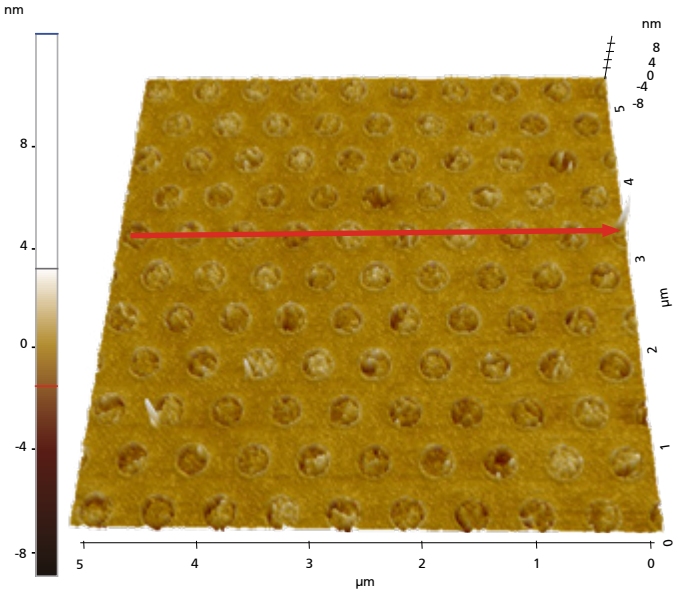
FiCM

Height



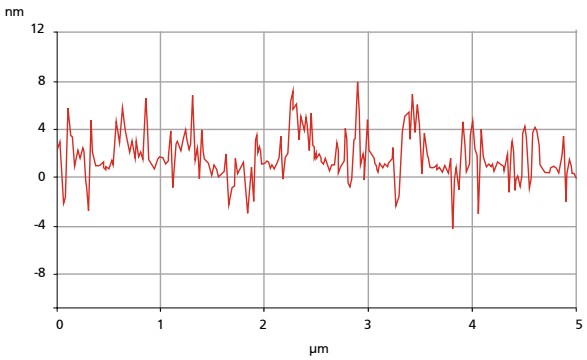
Peak to valley: 20.11 nm

3D Image



X:Y:Z scale = 1:1:50

Line profile

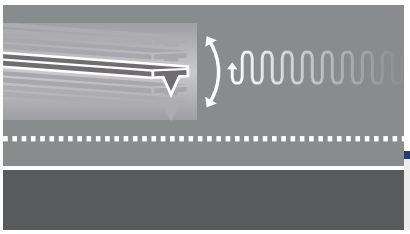


- Array type: Hexagonal
  Pad shape: Circle
  Pad size: 0.3 µm
  Pitch: 0.55 µm

Scanning conditions

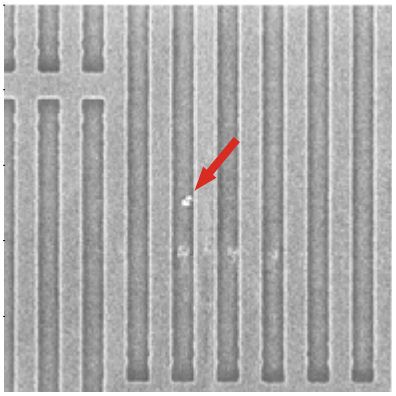
- System: NX-Wafer
- Scan Size: 5 µm × 5 µm
- Scan Mode: FiCM
- Scan Rate: 25 Hz
- Cantilever: biosphere B50-CONT (k=0.2 N/m, f=13 kHz)
- Pixel Size: 512 × 512

EUV Mask: Soft Defect Repair

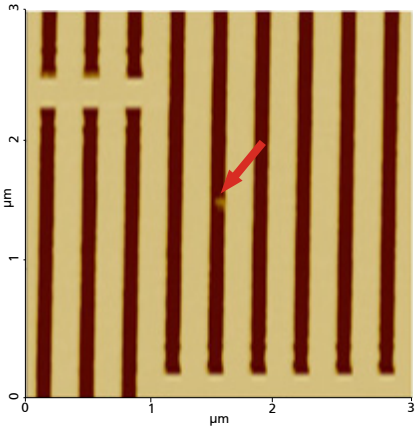


Non-contact, Mask Repair

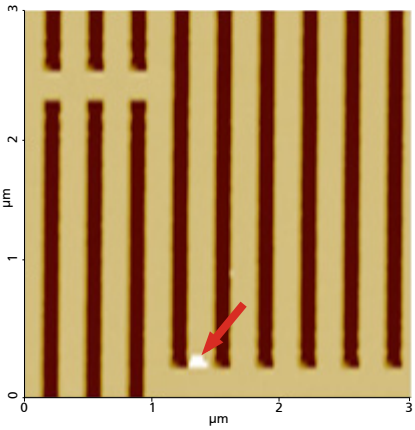
■ SEM



■ Height before Defect Repair



■ Height after Defect Repair

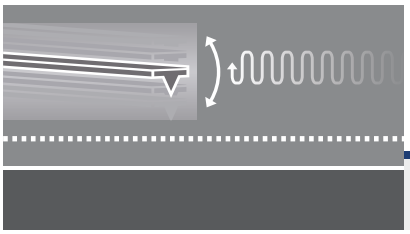


- Mask repair uses the AFM tip as a tool to effectively remove defects inside the trench structure. Additionally, by checking the results before and after the repair, both inspection and solution can be achieved.

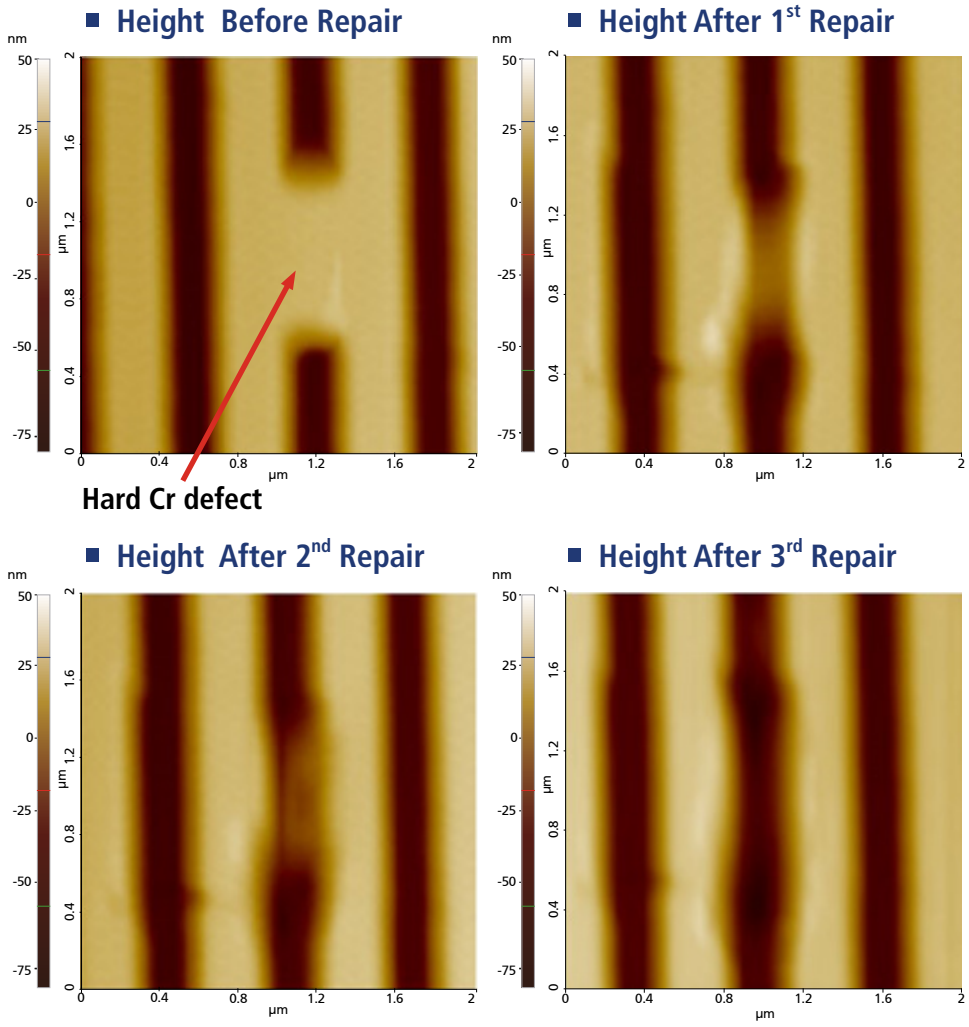
Scanning conditions

- System: NX-Mask
- Scan Size: All 3 µm × 3 µm
- Scan Mode: Non-contact, Mask Repair
- Scan Rate: All 0.2 Hz
- Cantilever: AD-40-AS (k=40 N/m, f=200 kHz)
- Pixel Size: All 512 × 128

EUV Mask: Hard Defect Repair



Non-contact, Mask Repair

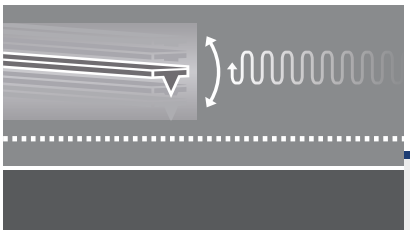


- Defects with patterns that are blocked in the middle can also be repaired using the AFM tip, essentially "carving" a path through the obstruction. In this way, various types of defects can be effectively removed.

Scanning conditions

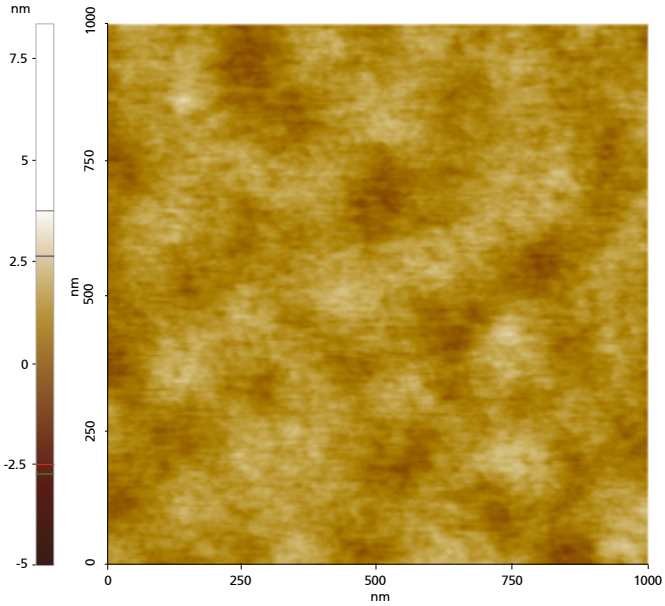
- System: NX-Mask
- Scan Size: All 2 µm × 2 µm
- Scan Mode: Non-contact, Mask Repair
- Scan Rate: All 0.2 Hz
- Cantilever: AD-450-AS (k=450 N/m, f=750 kHz)
- Pixel Size: All 512 × 128

Semiconductor Failure Analysis



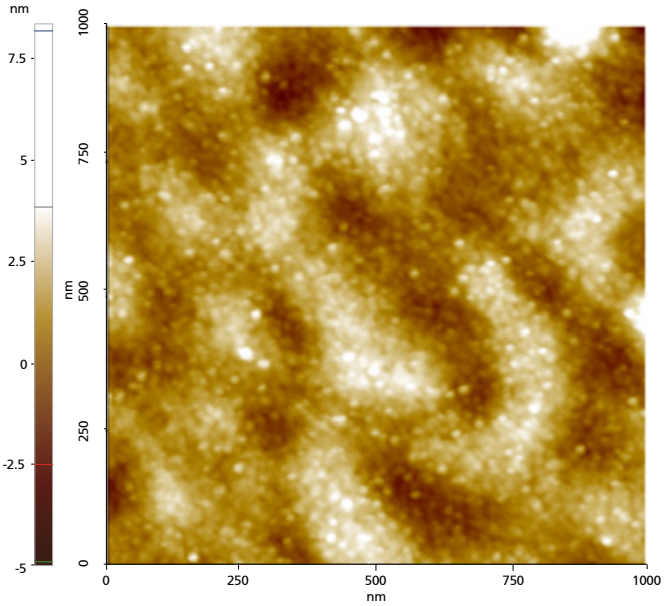
Non-contact

Height of Pass Sample



Peak to valley: 5.32 nm

Height of Fail Sample



Peak to valley: 12.8 nm

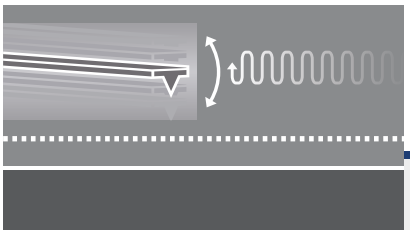
- A flat, low-roughness silicon wafer enhances semiconductor performance, lithography precision, optical clarity, and wafer bonding by ensuring uniform thin-film deposition, reducing defects, minimizing light scattering, and improving adhesion.

  AFM enables precise nanoscale surface characterization, allowing accurate measurement of roughness, detection of defects, and optimization of wafer processing.

Scanning conditions

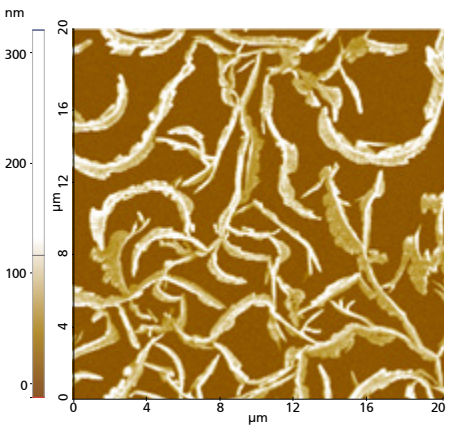
- System: FX200
- Scan Size: All 1 µm × 1 µm
- Scan Mode: Non-contact
- Scan Rate: All 3 Hz
- Cantilever: AC55TS (k=85 N/m, f=1600 kHz)
- Pixel Size: All 512 × 512

Organic Molecules



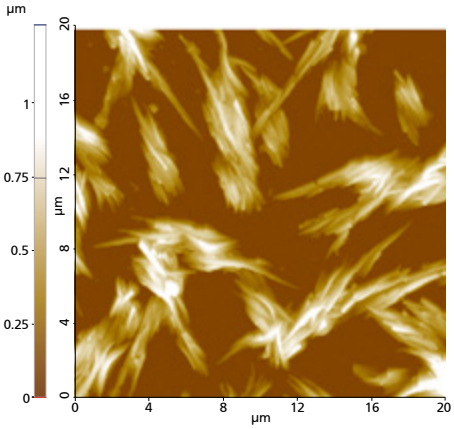
Non-contact

■ **Height of C_2Ph@RT**



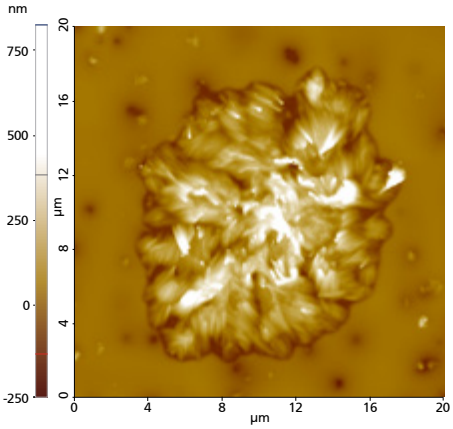
Peak to valley: 339 nm

■ **Height of Anealed C_2Ph**



Peak to valley: 562 nm

■ **Height of ClPh@RT**



Peak to valley: 106 nm

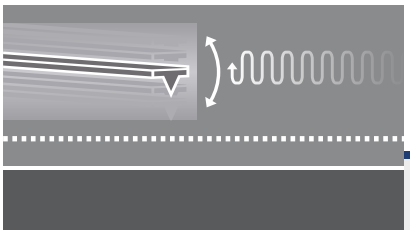
- C_2Ph refers to an organic molecular structure where a phenyl group (-Ph, or C_6H_5) is attached to a C_2 (two-carbon) unit.

  Molecules affect its structural, electronic, and optical properties depending on the thermal processing.

Scanning conditions

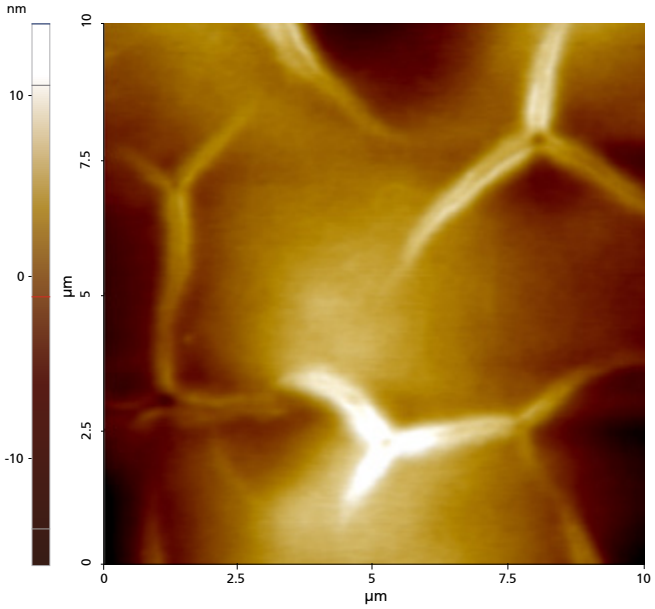
- System: FX200
- Scan Size: All 20 µm × 20 µm
- Scan Mode: Non-contact
- Scan Rate: All 0.5 Hz
- Cantilever: SCOUT 350 (k=42 N/m, f=350 kHz)
- Pixel Size: All 512 × 256

Hydrogel



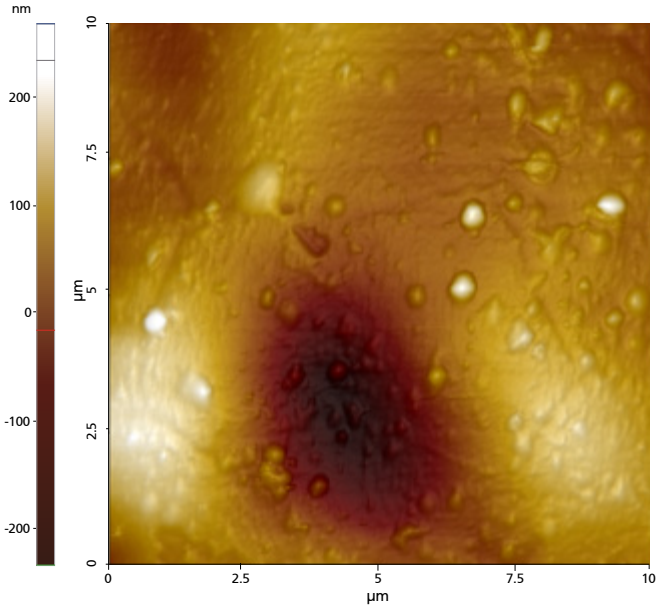
Non-contact, Liquid

Height of Dry Condition



Peak to valley: 33 nm

Height of In Liquid Condition



Peak to valley: 504 nm

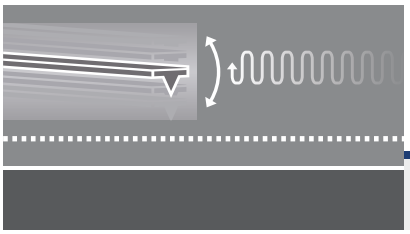
- The surface morphology of a hydrogel differs significantly between its dry condition and in-liquid condition due to its inherent water absorption and swelling properties.

  It influences the hydrogel's mechanical, optical, and functional properties in various applications such as biomedicine, sensors, and soft robotics.

Scanning conditions

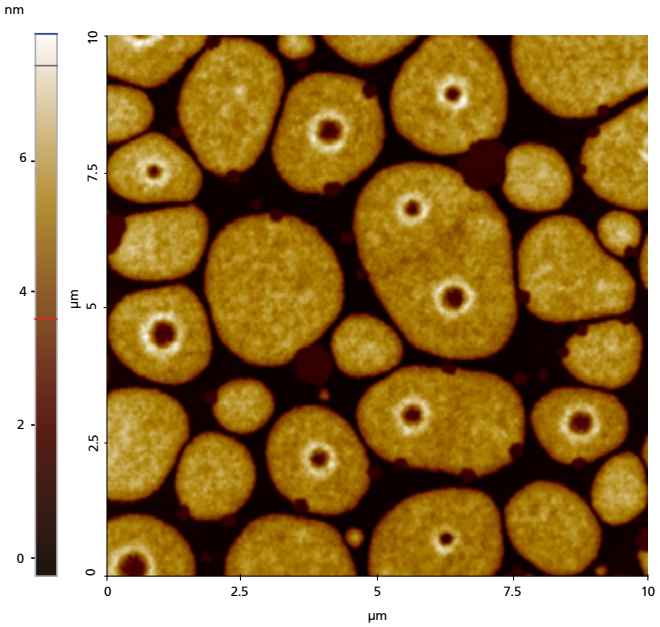
- System: FX200
- Scan Size: All 10 µm × 10 µm
- Scan Mode: Non-contact, Liquid
- Scan Rate: 0.5 Hz, 1 Hz
- Cantilever: AC40TS (k=0.09 N/m, f=110 kHz)
- Pixel Size: All 512 × 256

Polymer Composite



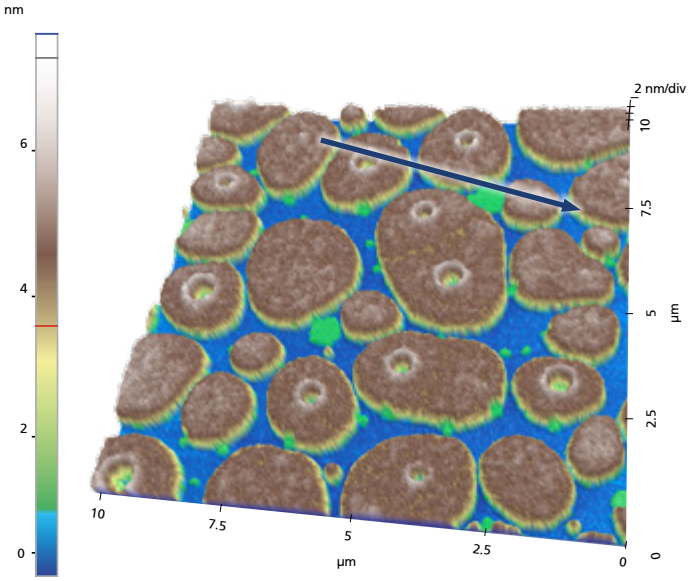
Non-contact

Height



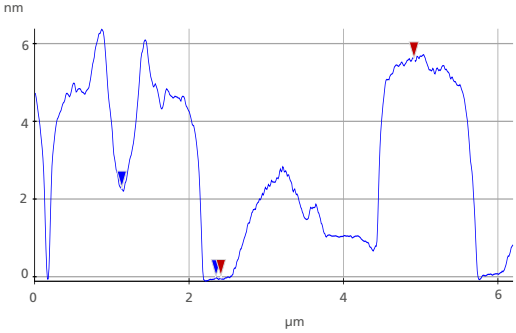
Peak to valley: 8.2 nm

3D Image



X:Y:Z scale = 1:1:100

Line profile

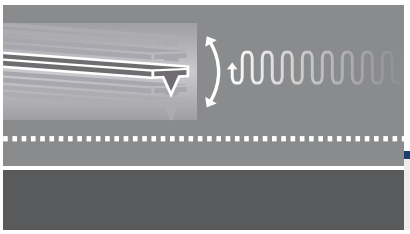


Cursor	ΔY(nm)
Red	5.615
Blue	2.260

Scanning conditions

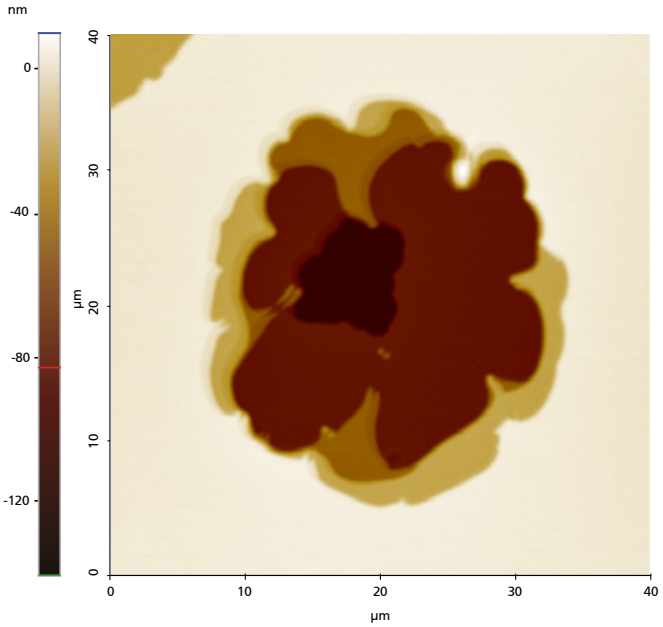
- System: FX200
- Scan Size: 10 µm × 10 µm
- Scan Mode: Non-contact
- Scan Rate: 0.5 Hz
- Cantilever: AC160TS (k=26 N/m, f=300 kHz)
- Pixel Size: 512 × 512

Self-assembled Block Copolymer



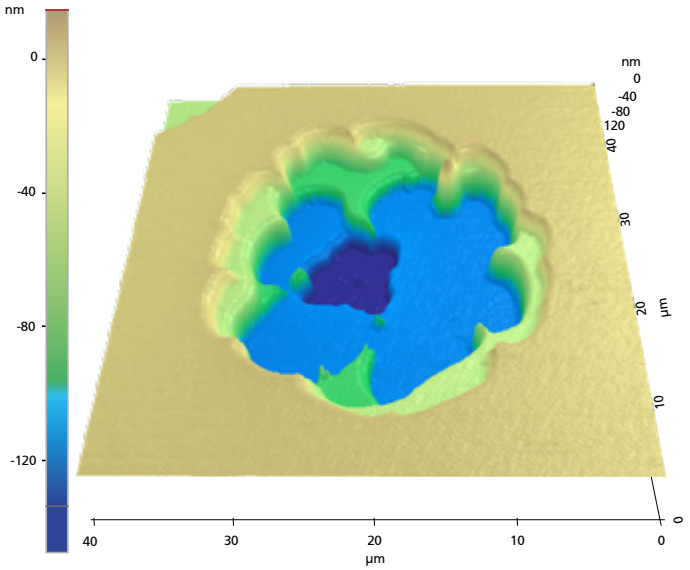
Non-contact

Height



Peak to valley: 150 nm

3D Image



X:Y:Z scale = 1:1:50

- For self-assembled block copolymer study by AFM, Analyze the surface morphology, such as lamellae, cylinders, or spheres.

  Quantify periodicity, domain sizes, and spacing of the nanoscale structures.

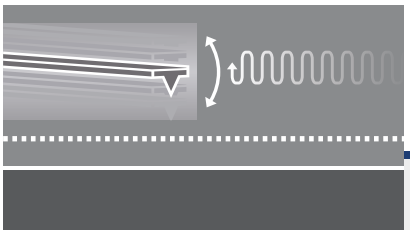
  Determine the surface roughness and uniformity of the assembled layers.

• Sample courtesy: Min-Hwa Kang, UOS Center for Research Facilities, Korea

Scanning conditions

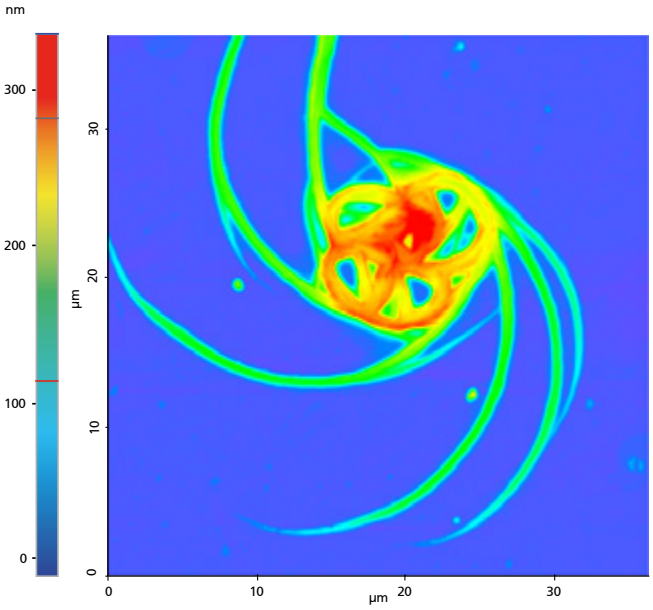
- System: NX10
- Scan Size: 40 μm × 40 μm
- Scan Mode: Non-contact
- Scan Rate: 0.3 Hz
- Cantilever: Multi75-G (k=3 N/m, f=75 kHz)
- Pixel Size: 256 × 256

Hyper-branched Polymer



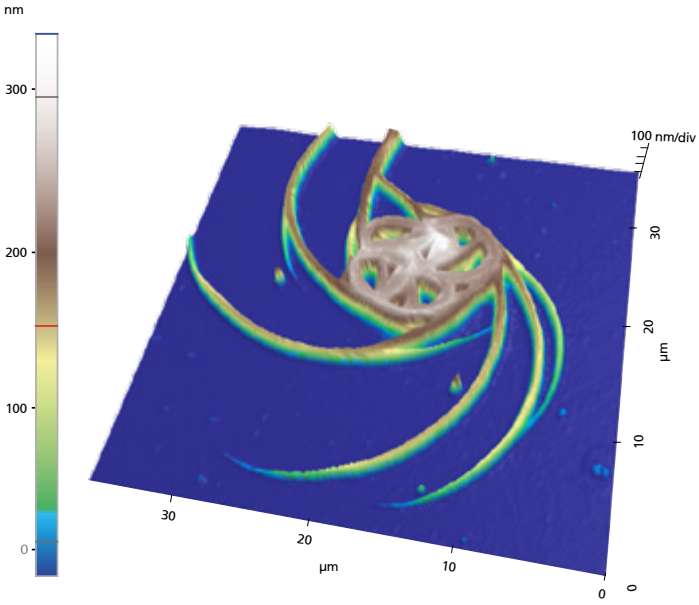
Non-contact

Height



Peak to valley: 378 nm

3D Image



X:Y:Z scale = 1:1:10

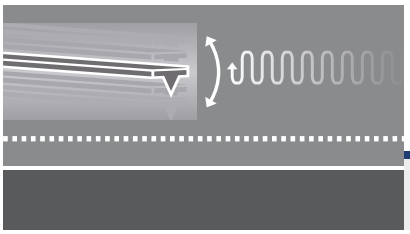
- Hyper-branched polymers (HBPs) are highly branched, 3D macromolecules with numerous reactive chain-ends and low viscosity, making them versatile for various applications such as coatings, adhesives, and nanotechnology.

  Their unique structure also provides high solubility and internal cavities for encapsulating other molecules.

Scanning conditions

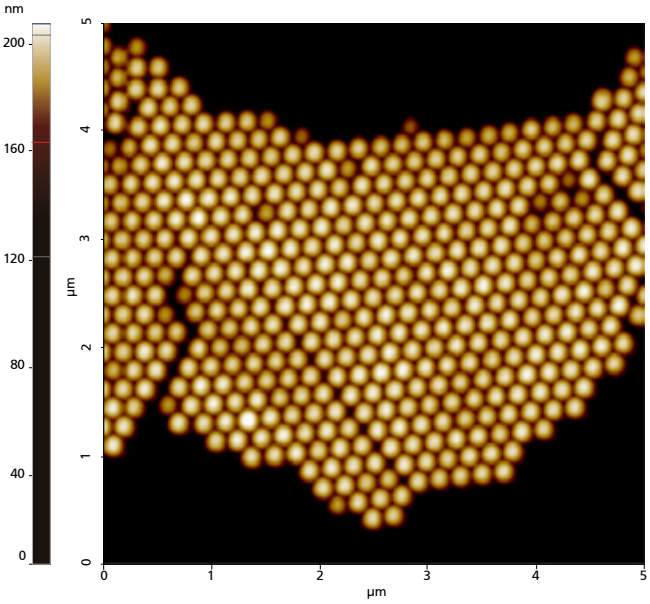
- System: FX200
- Scan Size: 35 µm × 35 µm
- Scan Mode: Non-contact
- Scan Rate: 0.2 Hz
- Cantilever: AC40TS (k=0.09 N/m, f=110 kHz)
- Pixel Size: 512 × 512

Polystyrene Beads on Mica



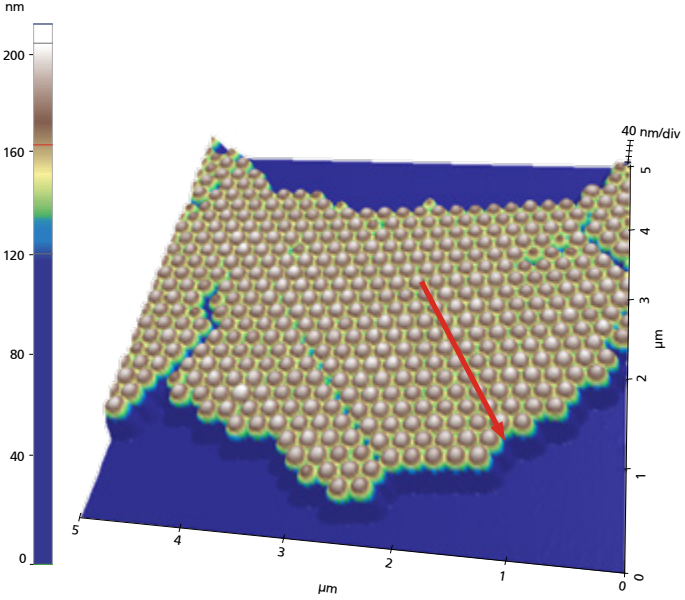
Non-contact

Height



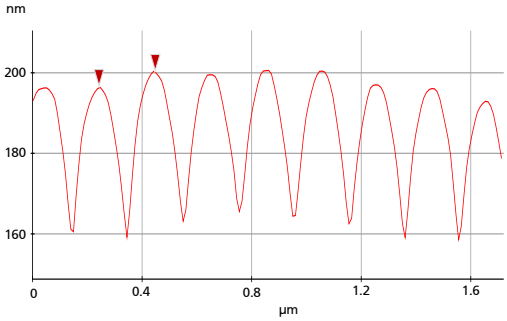
Peak to valley: 210.5 nm

3D Image



X:Y:Z scale = 1:1:2

Line Profile



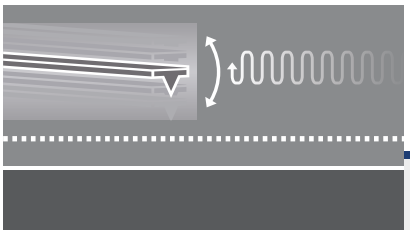
- NIST Traceable Nanosphere size standards
  - Certified diameter 203 nm ± 5 nm

Cursor	ΔX(µm)
Red	0.204

Scanning conditions

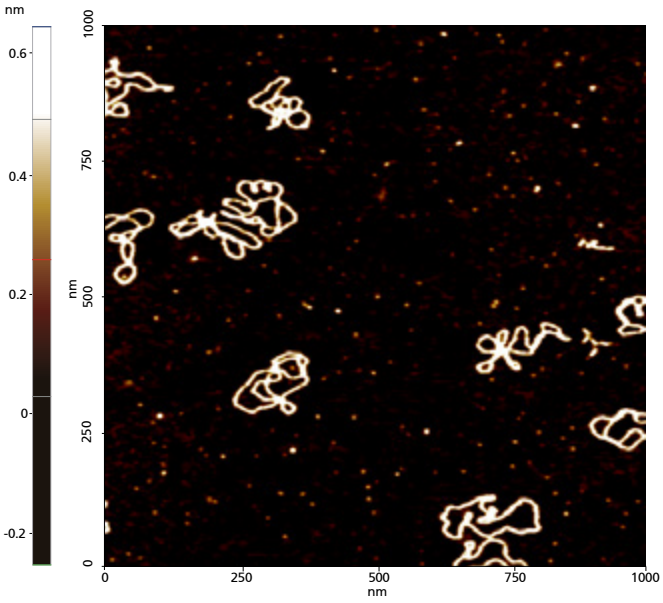
- System: FX200
- Scan Size: 5 µm × 5 µm
- Scan Mode: Non-contact
- Scan Rate: 0.16 Hz
- Cantilever: SCOUT 350 (k=42 N/m, f=350 kHz)
- Pixel Size: 512 × 512

mRNA



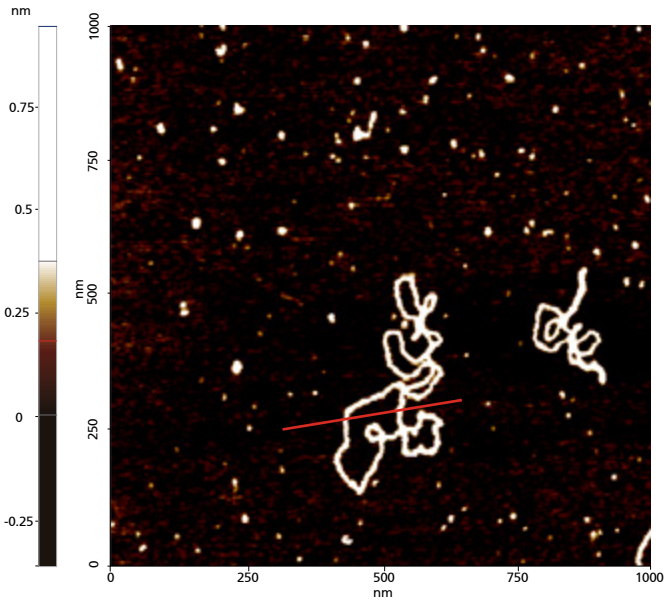
Non-contact in air

Height of Position 1



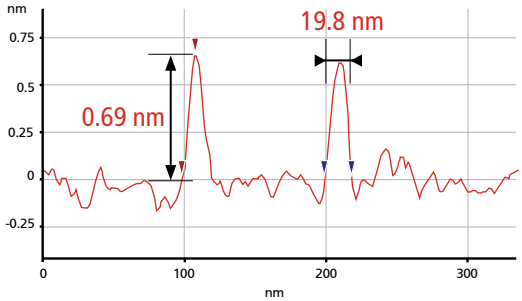
Peak to valley: 0.91 nm

Height of Position 2



Peak to valley: 1.31 nm

Line Profile



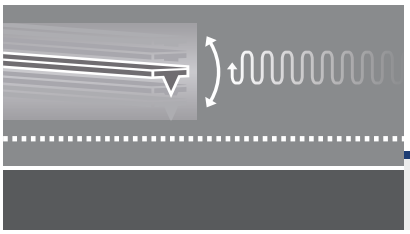
- RNA (mRNA) is a type of single-stranded RNA that carries genetic information from DNA to the ribosomes, where proteins are synthesized.

• Sample courtesy: Dr. Hizume, Central Research Facility, Saitama Medical univ., Japan

Scanning conditions

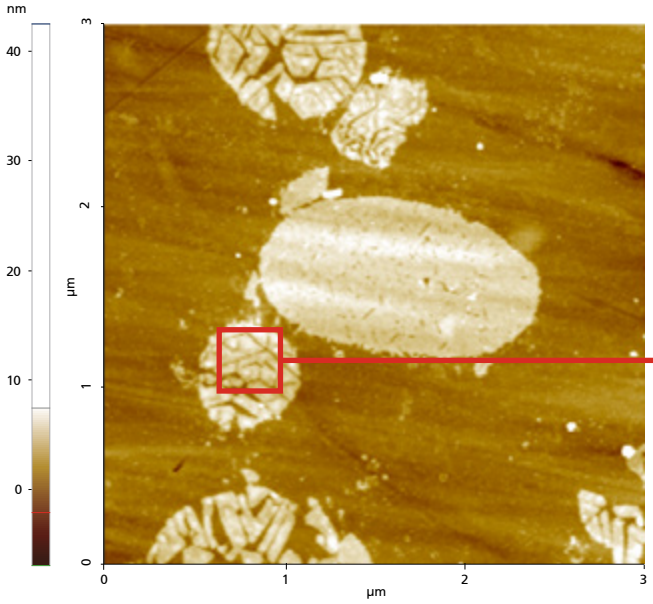
- System: NX10
- Scan Size: All 1 µm × 1 µm
- Scan Mode: Non-contact in air
- Scan Rate: All 1 Hz
- Cantilever: AC160TS (k=26 N/m, f=300 kHz)
- Pixel Size: All 512 × 512

Purple Membrane (film) of Bacteriorhodopsin (BR)



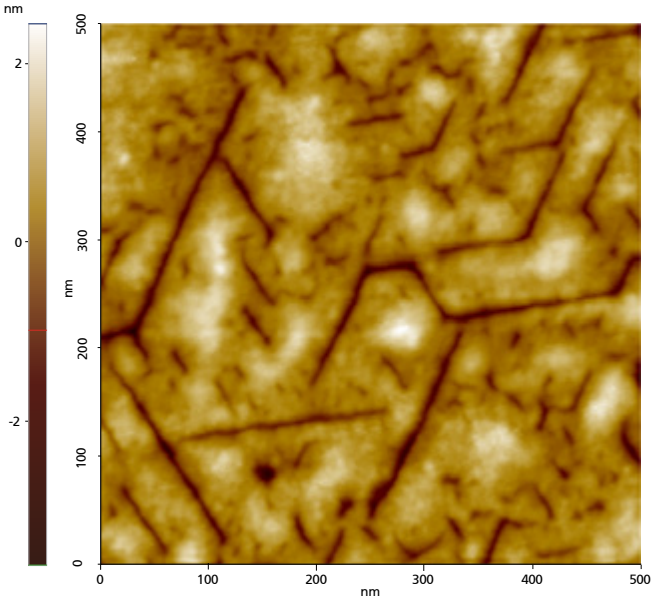
Non-contact

Height



Peak to valley: 49.5 nm

Zoom-in Height



Peak to valley: 6.04 nm

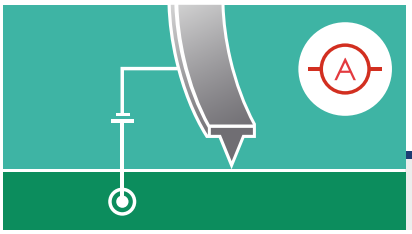
- The purple membrane of bacteriorhodopsin is a naturally occurring biofilm with extraordinary photonic and bioenergetic properties.

  Its ability to convert light into a proton gradient without electron transport makes it a fascinating system for biophysics research and technological applications.

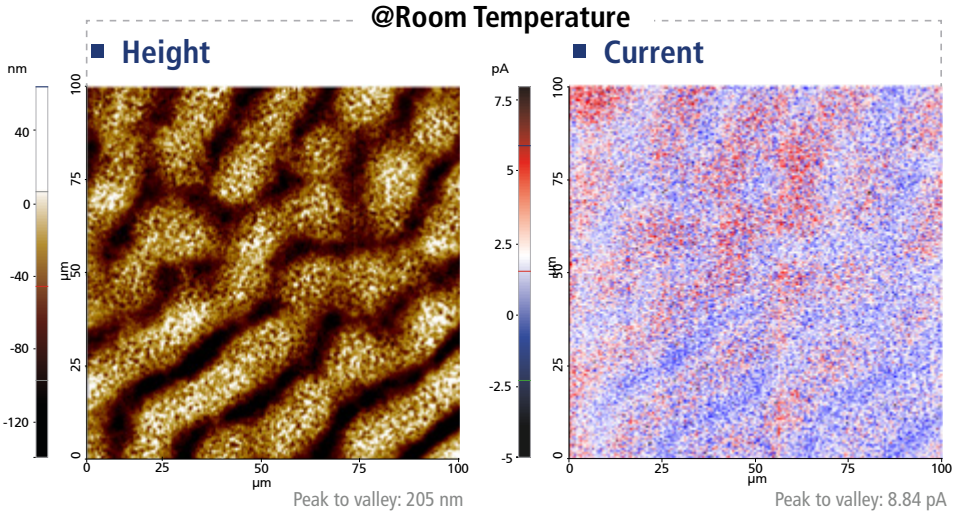
Scanning conditions

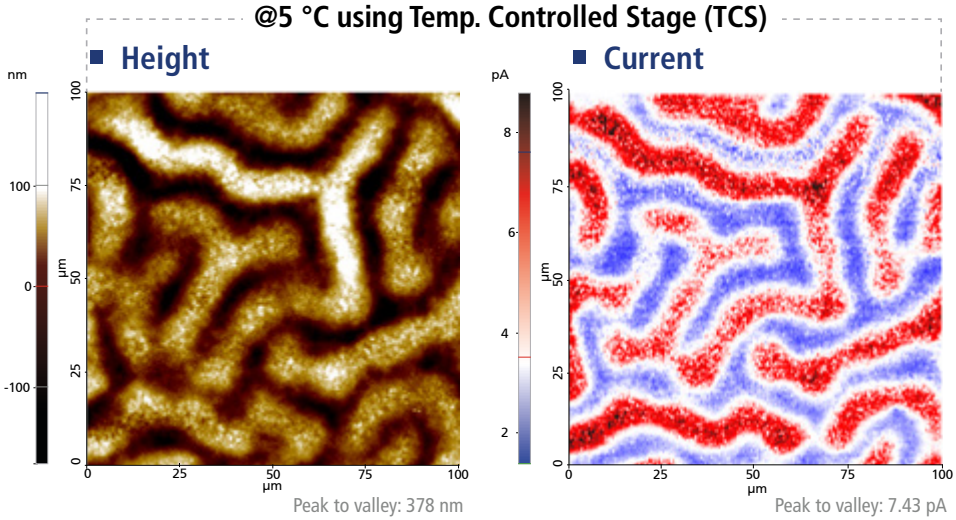
- System: FX200
- Scan Size: 3 µm × 3 µm, 0.5 µm × 0.5 µm
- Scan Mode: Non-contact
- Scan Rate: 0.5 Hz, 1 Hz
- Cantilever: AC160TS (k=26 N/m, f=300 kHz)
- Pixel Size: All 256 × 256

Perovskite



Conductive AFM, TCS



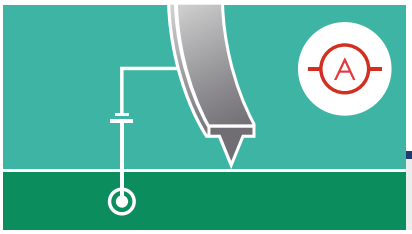


- Perovskites exhibit temperature-dependent electrical signals due to various mechanisms such as phase transitions, ion migration, changes in charge transport properties, and thermally stimulated currents.

Scanning conditions

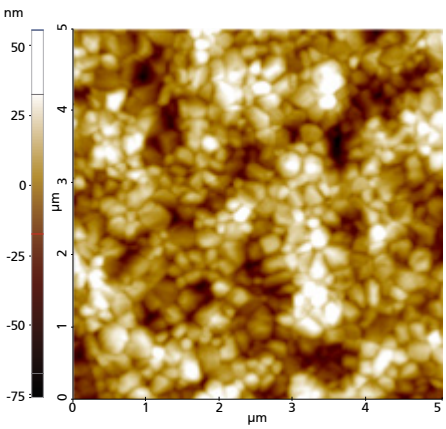
- System: FX200
- Scan Size: All 100 µm × 100 µm
- Scan Mode: Conductive AFM, TCS
- Scan Rate: : All 0.3 Hz
- Cantilever: CDT-CONTR (k=0.5 N/m, f=20 kHz)
- Pixel Size: All 512 × 256

Perovskite



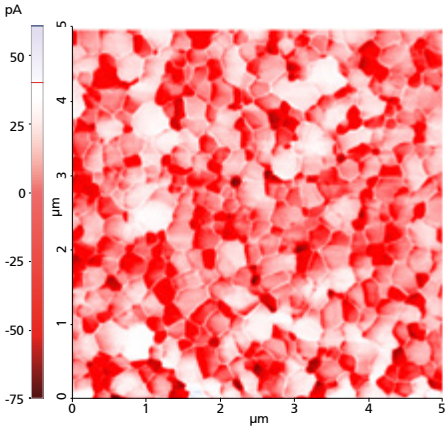
Conductive AFM

Height



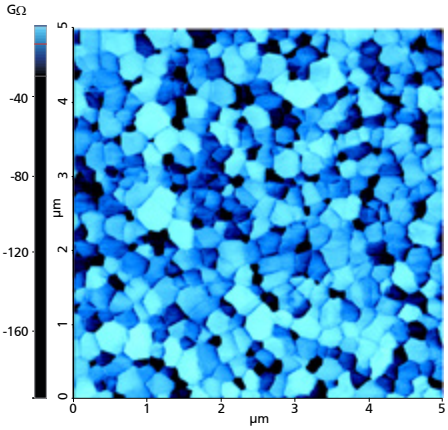
Peak to valley: 132 nm

Current



Peak to valley: 134.8 pA

Resistance



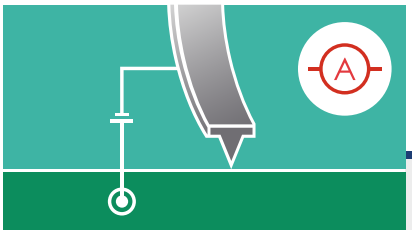
Peak to valley: 190 GΩ

• Sample courtesy: Kanajaboos Lab, Mahidol University, Thailand

Scanning conditions

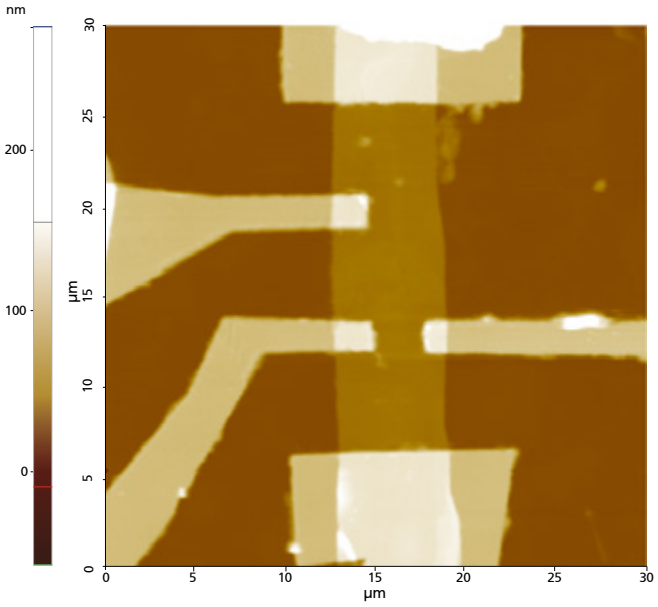
- System: NX10
- Scan Size: 5 µm × 5 µm
- Scan Mode: Conductive AFM
- Scan Rate: 0.25 Hz
- Cantilever: ANSCM-PC (k=0.2 N/m, f=12 kHz)
- Pixel Size: 512 × 512

WTe_2 on Au Electrode



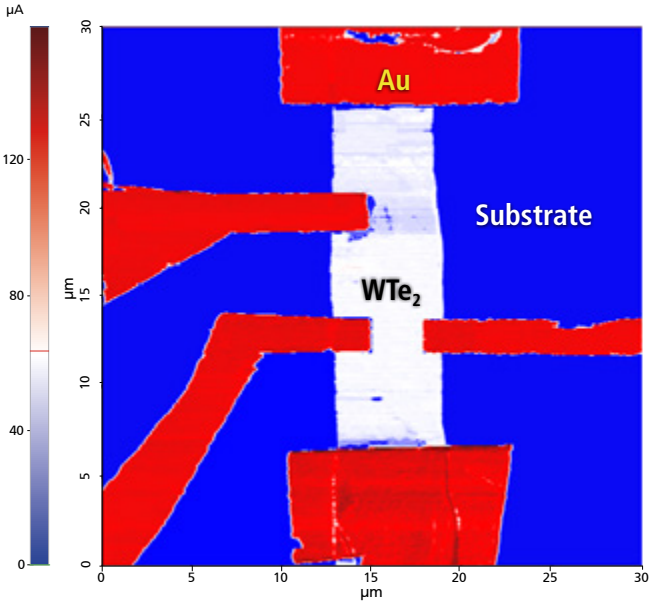
Conductive AFM

Height



Peak to valley: 370 nm

Current



Peak to valley: 158 µA

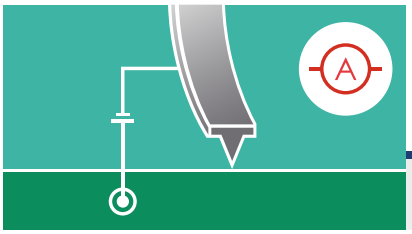
- WTe_2 is a transition metal dichalcogenide (TMD) that has gained significant attention in recent years due to its remarkable electrical properties, including its large magnetoresistance, topological behavior, and potential applications in next-generation electronic devices.

- Current Comparison
  Au > WTe_2 > Substrate

Scanning conditions

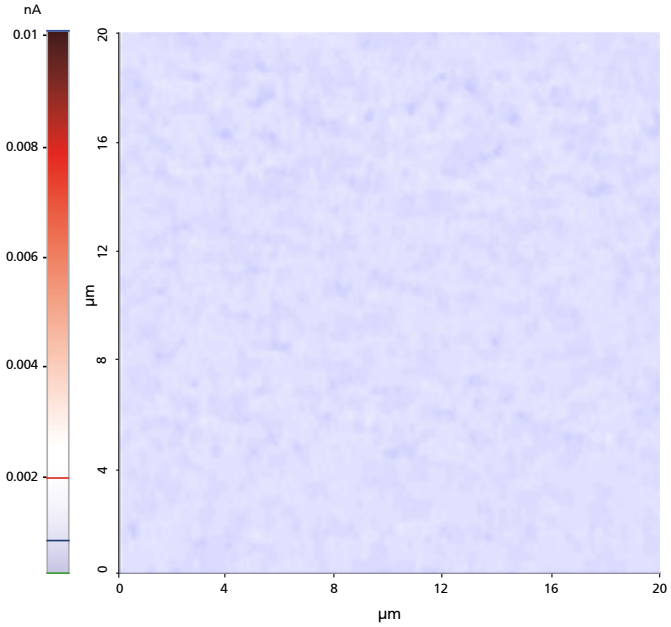
- System: FX200
- Scan Size: 30 µm × 30 µm
- Scan Mode: Conductive AFM
- Scan Rate: 1 Hz
- Cantilever: CDT-NCHR (k=80 N/m, f=400 kHz)
- Pixel Size: 1024 × 512

Leakage Current of Ceramic Layer



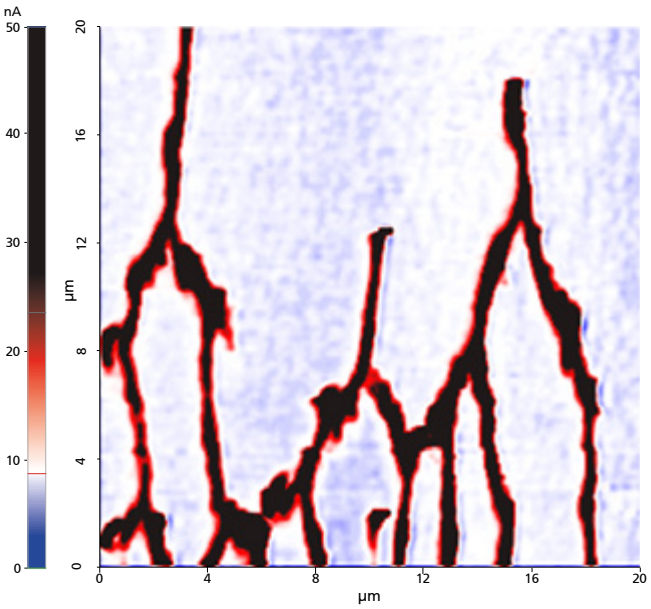
Conductive AFM

Current (Sample bias: 0 V)



Mean: 0.001 nA

Current (Sample bias: 50 V)



Mean: 11.5 nA

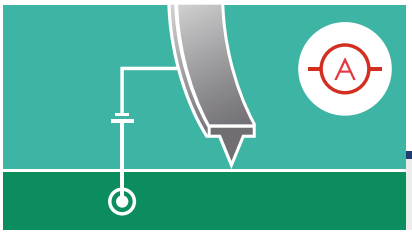
- The leakage current in a ceramic layer is the unwanted current that flows through the material due to imperfections in the dielectric properties.

  Comparing conditions of 0 V applied and high voltage applied, varies significantly due to several factors related to material characteristics and electrical stress.

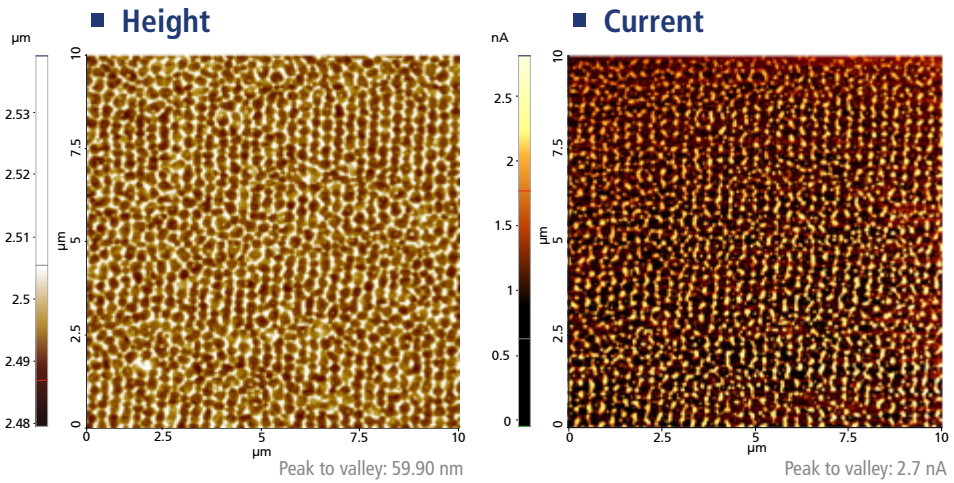
Scanning conditions

- System: FX200
- Scan Size: All 20 µm × 20 µm
- Scan Mode: Conductive AFM
- Scan Rate: All 1 Hz
- Cantilever: CDT-NCHR (k=80 N/m, f=400 kHz)
- Pixel Size: All 256 × 256

Poly Silicon



Conductive AFM

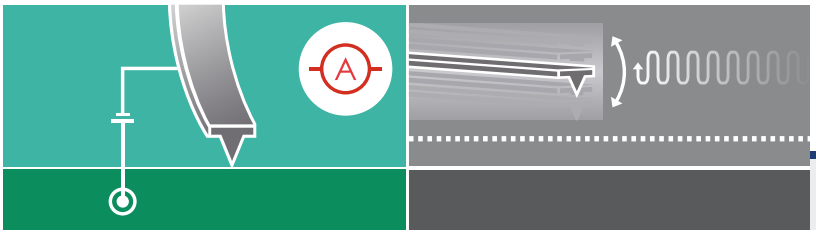


- Polycrystalline silicon is a material composed of multiple small silicon crystals or grains. It is commonly used in semiconductors, solar cells, and thin-film transistors due to its intermediate properties between crystalline silicon and amorphous silicon.

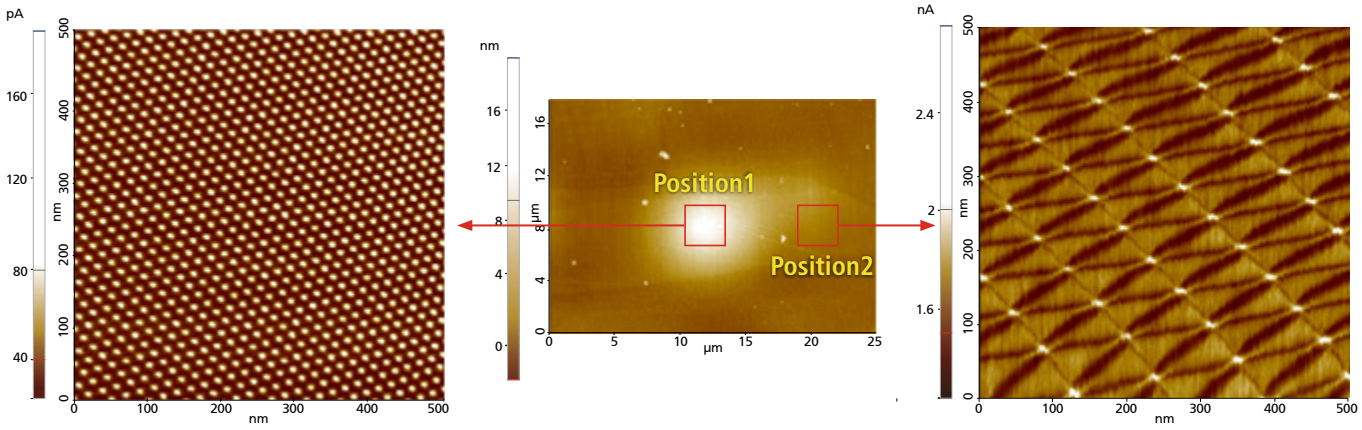
Scanning conditions

- System: FX200
- Scan Size: 10 µm × 10 µm , 2 µm × 2 µm
- Scan Mode: Conductive AFM
- Scan Rate: 0.4 Hz, 0.6 Hz
- Cantilever: AD-40-AS (k=40 N/m, f=200 kHz)
- Pixel Size: All 512 × 256

Trapped Bubble in Twisted Bilayer Graphene on hBN



Conductive AFM, Non-contact



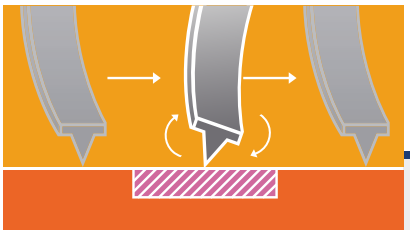
- Moiré patterns with different periods were observed at the two positions. The difference in periodicity is associated with different stacking registries.

- More information: https://www.parksystems.com/en/learning-center/lc-detail.appnote_97

Scanning conditions

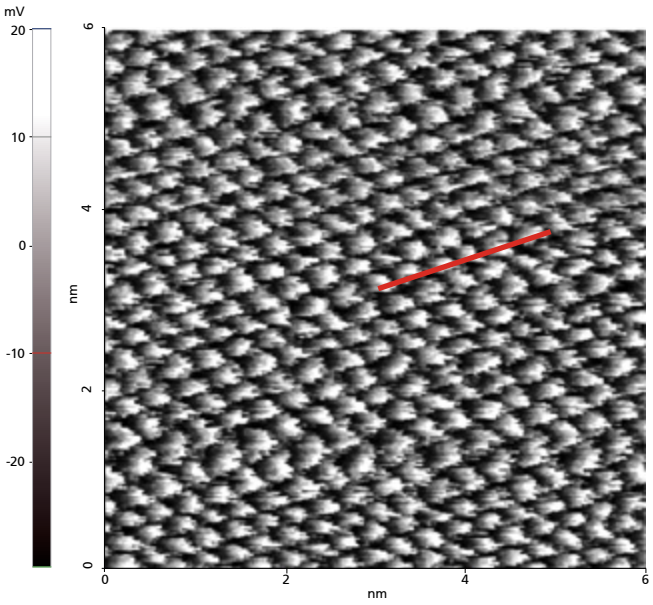
- System: FX200
- Scan Size: 500 nm × 500 nm, 25 μm × 18 μm
- Scan Mode: Conductive AFM, Non-contact
- Scan Rate: 10 Hz, 0.6 Hz
- Cantilever: SPARK 70 Pt (k=2 N/m, f=70 kHz)
- Pixel Size: All 512 × 256

MoS_2 Atomic Lattice Structure

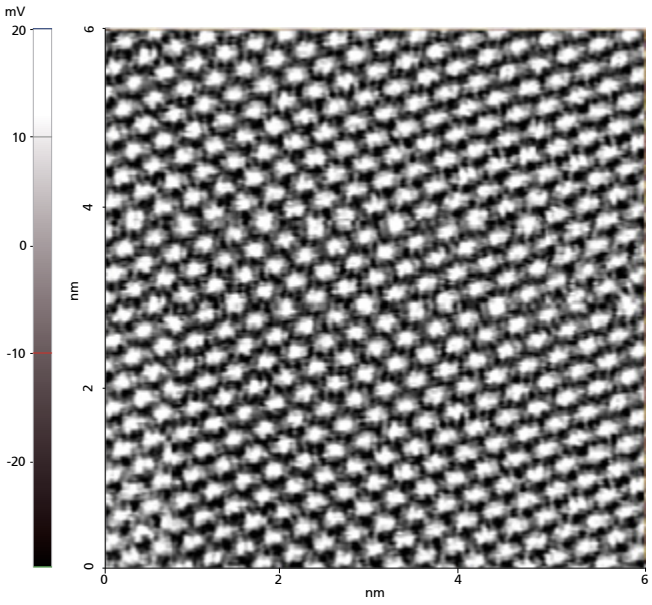


LFM

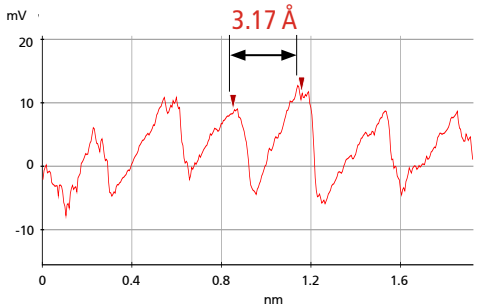
Lateral (C-D)



Lateral (C-D) FTT filtered



Line Profile

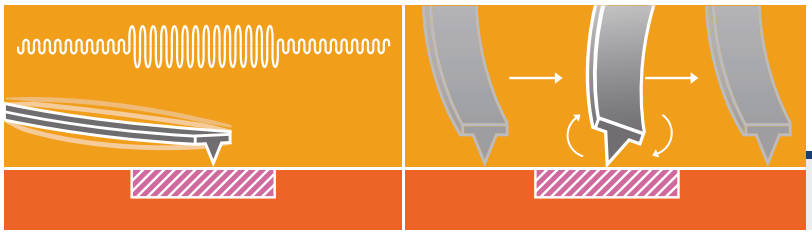


- Ref. lattice constant ~3.16 Å

Scanning conditions

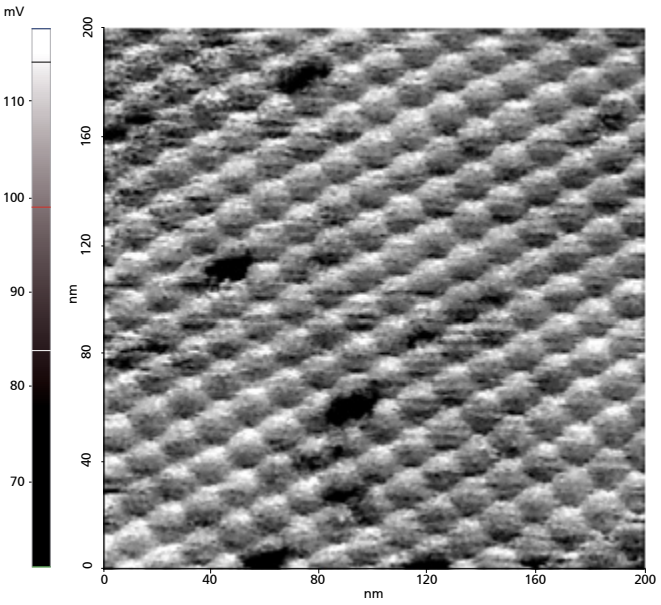
- System: NX10
- Scan Size: 6 nm × 6 nm
- Scan Mode: LFM
- Scan Rate: 20 Hz
- Cantilever: SCOUT 70 (k=2 N/m, f=70 kHz)
- Pixel Size: 512 × 512

Single Layer Graphene on hBN

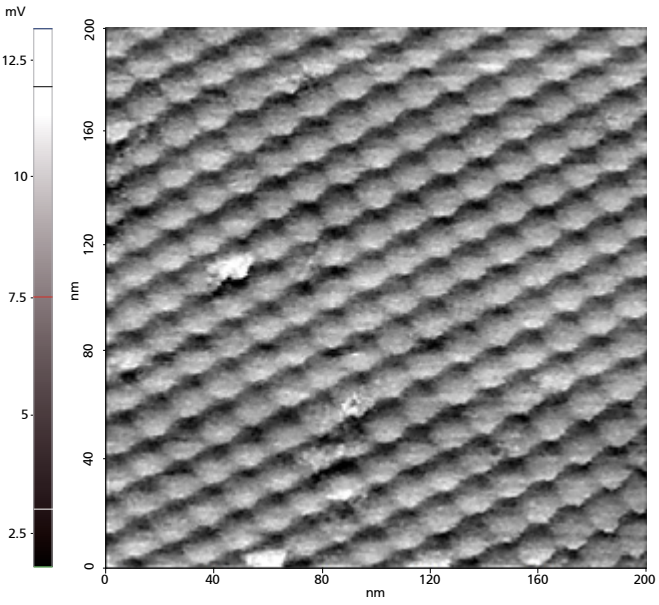


FMM, LFM

FMM Amplitude



Lateral (C-D)



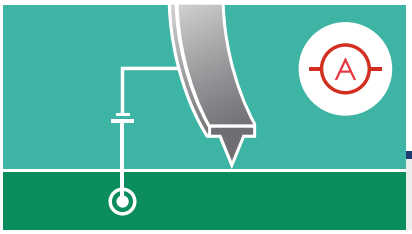
- Graphene has a lattice constant of ~2.46 Å, while hBN has a slightly larger lattice constant of ~2.50 Å (a mismatch of ~1.8%).

  When single-layer graphene is placed on a hexagonal boron nitride (hBN) substrate, a moiré pattern forms due to the slight mismatch in lattice constants and relative rotational misalignment between the two layers.

Scanning conditions

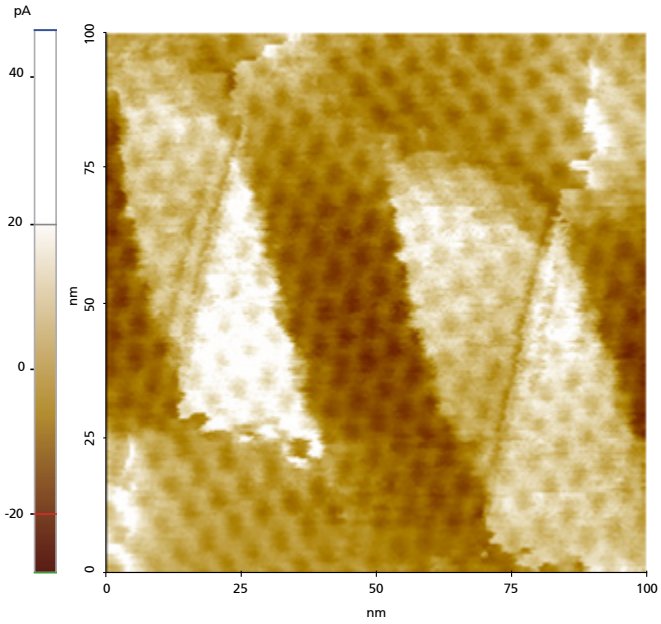
- System: FX200
- Scan Size: All 200 nm × 200 nm
- Scan Mode: FMM, LFM
- Scan Rate: All 5 Hz
- Cantilever: AC240TS (k=2 N/m, f=70 kHz)
- Pixel Size: All 512 × 512

Moiré Pattern in Twisted Bilayer Graphene on hBN

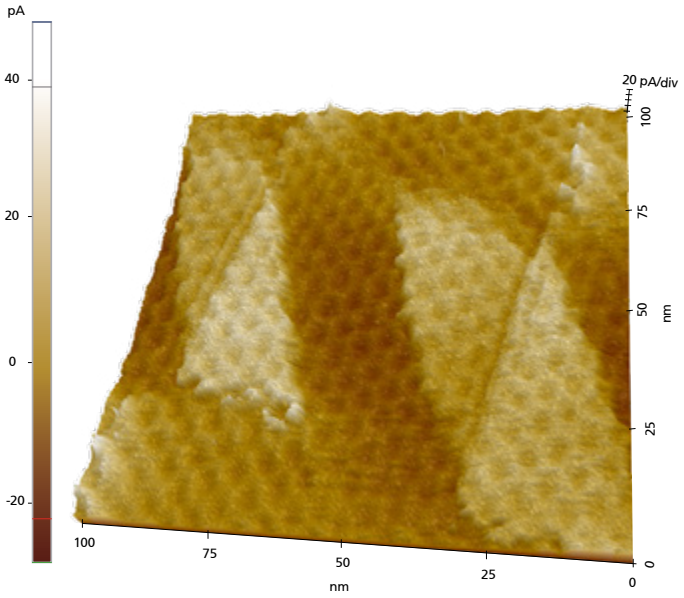


Conductive AFM

Current



3D Image



X:Y:Z scale = 1:1:0.1

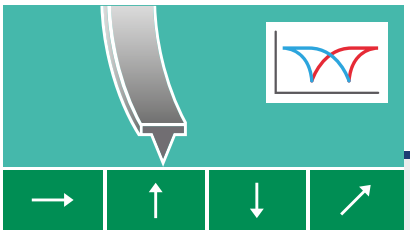
- When twisted bilayer graphene is placed on hBN, the two moiré patterns interfere, leading to a dual moiré superlattice.

  Depending on the relative twist angles and lattice mismatches, the dual moiré system can exhibit regions where the patterns are commensurate (aligned) or incommensurate (disordered).

Scanning conditions

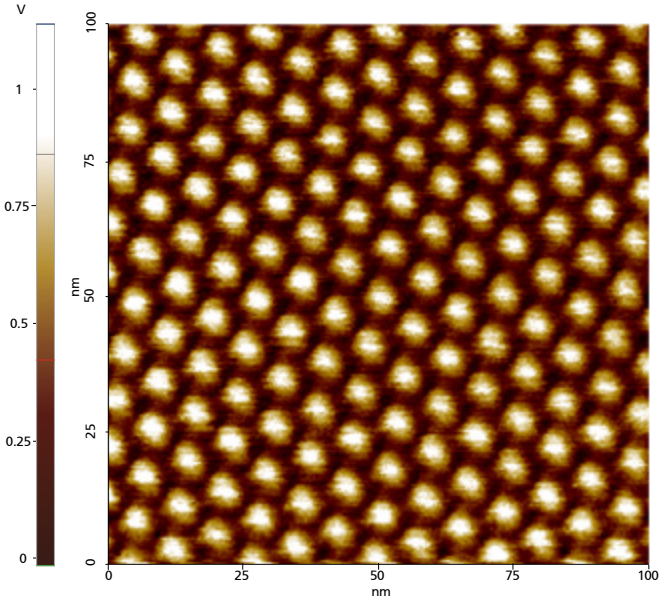
- System: FX200
- Scan Size: 100 nm × 100 nm
- Scan Mode: Conductive AFM
- Scan Rate: 3 Hz
- Cantilever: AD-2.8-AS (k=2.8 N/m, f=75 kHz)
- Pixel Size: 256 × 256

Moiré Pattern in Twisted Bilayer Graphene on hBN

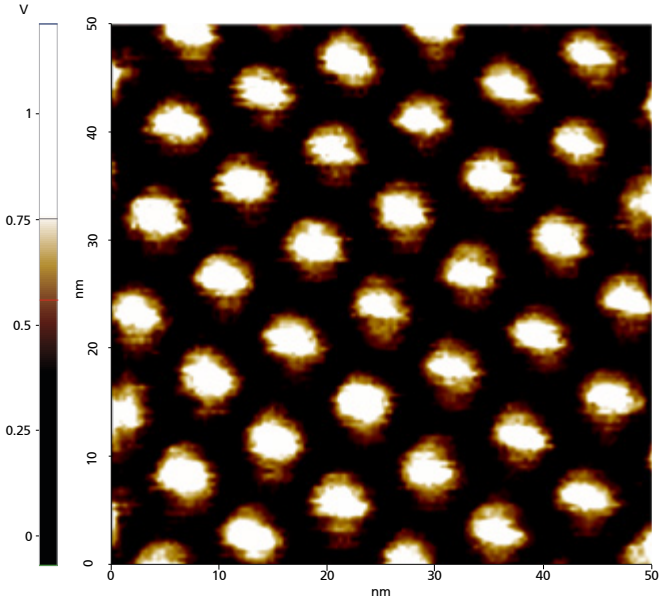


CR-PFM

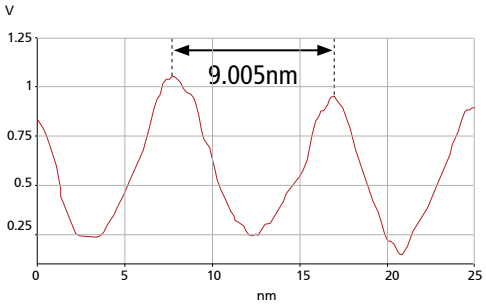
PFM Amplitude



Zoom-in PFM Amplitude



Line Profile



- A moiré pattern forms due to the combined effects of lattice mismatch and the twist angle between the two graphene layers.

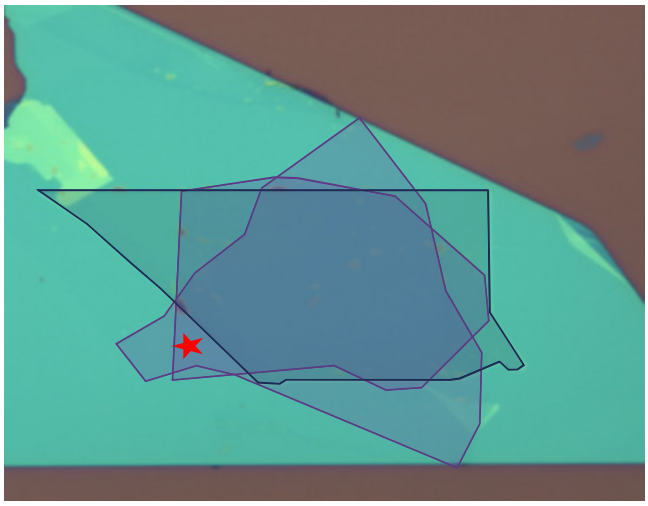
Scanning conditions

- System: FX200
- Scan Size: 100 nm × 100 nm, 50 nm × 50 nm
- Scan Mode: CR-PFM
- Scan Rate: All 2.5 Hz
- Cantilever: SPARK 70 Pt (k=2 N/m, f=70 kHz)
- Pixel Size: 256 × 256, 512 × 512

Moiré Pattern in Twisted Bilayer Graphene on hBN

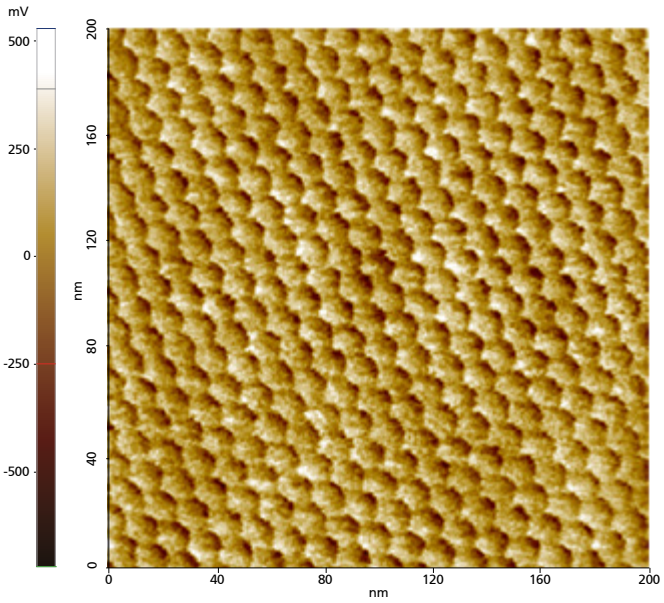
sMIM

Optical view: tBG coverd with hBN



★ Measured area

sMIM Resistance



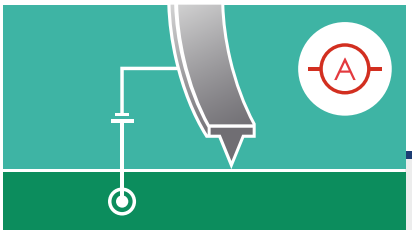
- sMIM offers sub-nanometer spatial resolution, which is crucial for capturing the fine details of the moiré pattern in twisted bilayer graphene.

  This high resolution allows for precise imaging of the interlayer stacking and the interference patterns that emerge from the periodic lattice mismatch between the two graphene layers

Scanning conditions

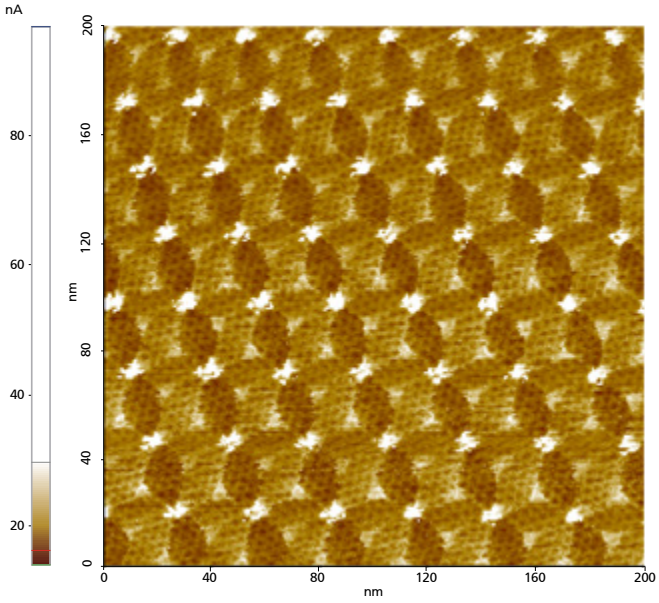
- System: NX20
- Scan Size: 200 nm × 200 nm
- Scan Mode: sMIM
- Scan Rate: 3 Hz
- Cantilever: sMIM (Short) (k=8 N/m, f=75 kHz)
- Pixel Size: 512 × 512

Moiré Superlattice in Twisted Bilayer Graphene on hBN

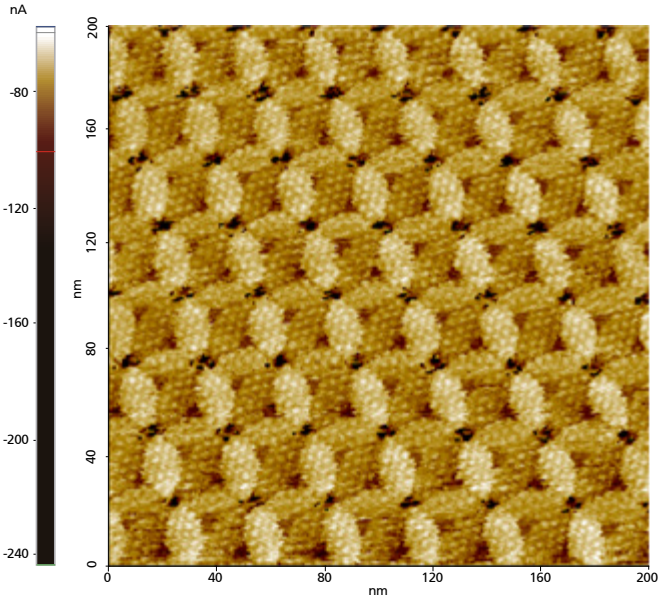


Conductive AFM

Current (Sample bias: 0.05 V)



Current (Sample bias: -0.05 V)



- When twisted bilayer graphene is placed on hBN, the two moiré patterns interfere, leading to a dual moiré superlattice.

  Depending on the relative twist angles and lattice mismatches, the dual moiré system can exhibit regions where the patterns are commensurate (aligned) or incommensurate (disordered).

• Sample courtesy: Prof.Tomoki Machida, Yuta Seo, Institute of Industrial Science, University of Tokyo, Japan

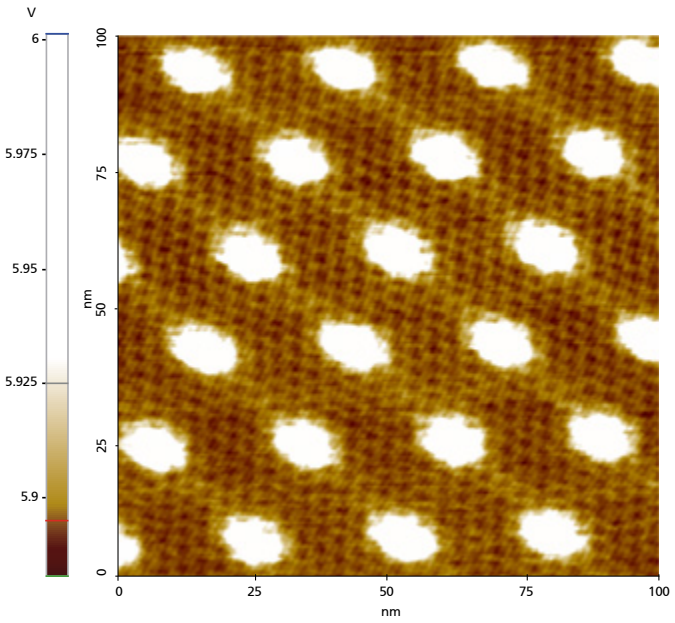
Scanning conditions

- System: FX200
- Scan Size: All 200 nm × 200 nm
- Scan Mode: Conductive AFM
- Scan Rate: All 4 Hz
- Cantilever: SPARK 70 Pt (k=2.0 N/m, f=70 kHz)
- Pixel Size: All 512 × 256

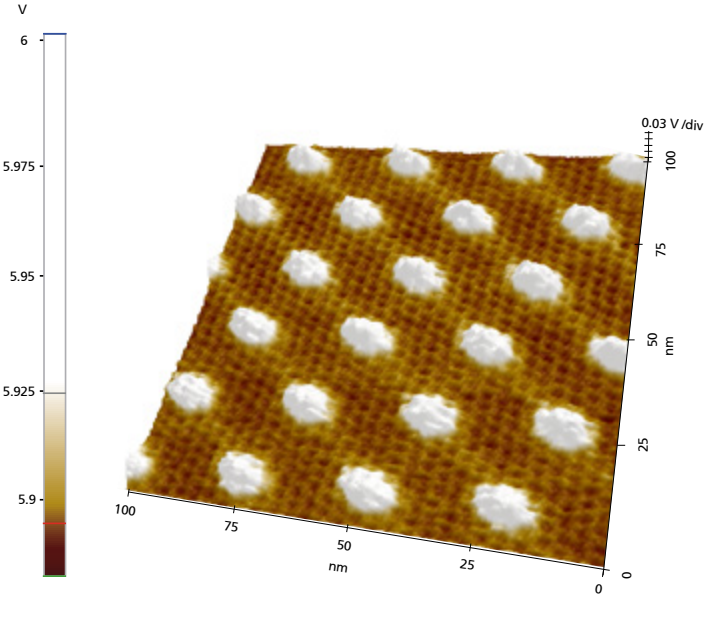
Moiré Superlattice in Twisted Bilayer Graphene on hBN

sMIM

sMIM Capacitance



3D Image



X:Y:Z scale = 1:1:0.1

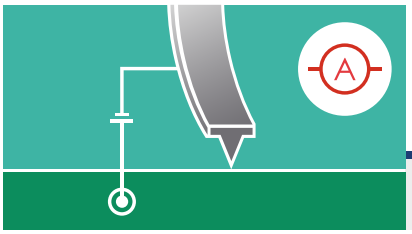
- When twisted bilayer graphene is placed on hBN, the two moiré patterns interfere, leading to a dual moiré superlattice.

  Depending on the relative twist angles and lattice mismatches, the dual moiré system can exhibit regions where the patterns are commensurate (aligned) or incommensurate (disordered).

Scanning conditions

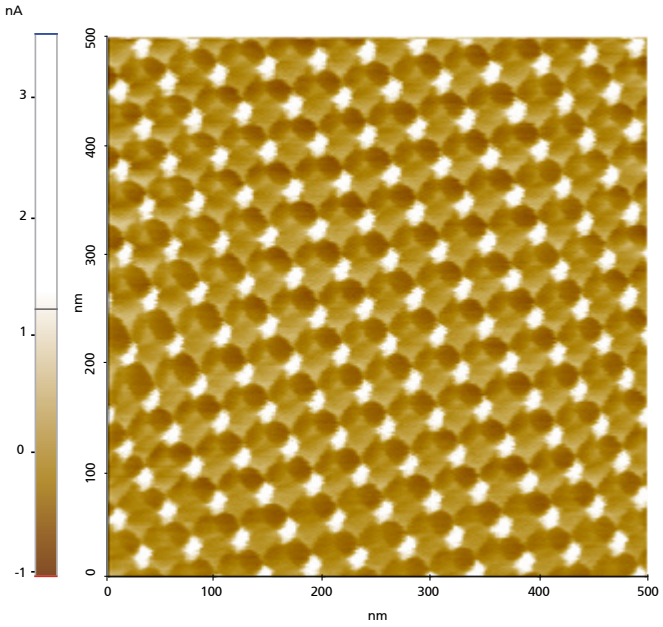
- System: FX200
- Scan Size: 100 nm × 100 nm
- Scan Mode: sMIM
- Scan Rate: 5 Hz
- Cantilever: sMIM (Short) (k=8 N/m, f=75 kHz)
- Pixel Size: 1024 × 1024

Moiré Superlattice in Twisted Bilayer Graphene on hBN

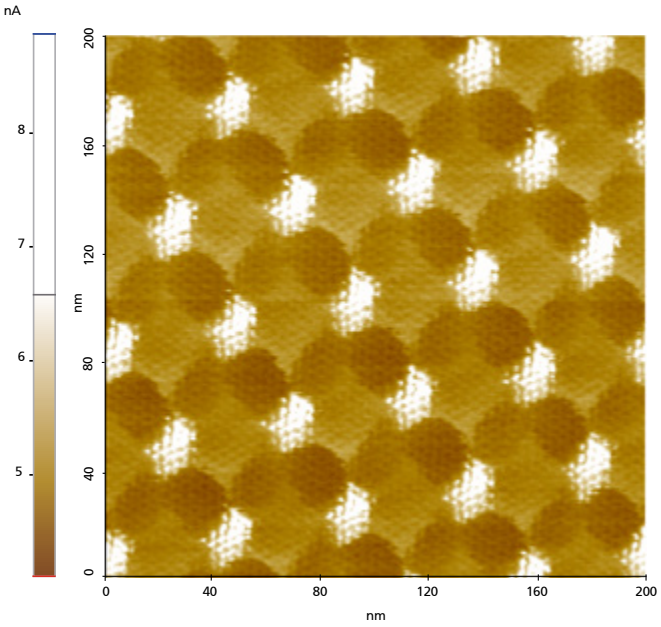


Conductive AFM

Current



Zoom-in Current



- When twisted bilayer graphene is placed on hBN, the two moiré patterns interfere, leading to a dual moiré superlattice.

  Depending on the relative twist angles and lattice mismatches, the dual moiré system can exhibit regions where the patterns are commensurate (aligned) or incommensurate (disordered).

• Sample courtesy: Prof.Tomoki Machida, Yuta Seo, Institute of Industrial Science, University of Tokyo, Japan

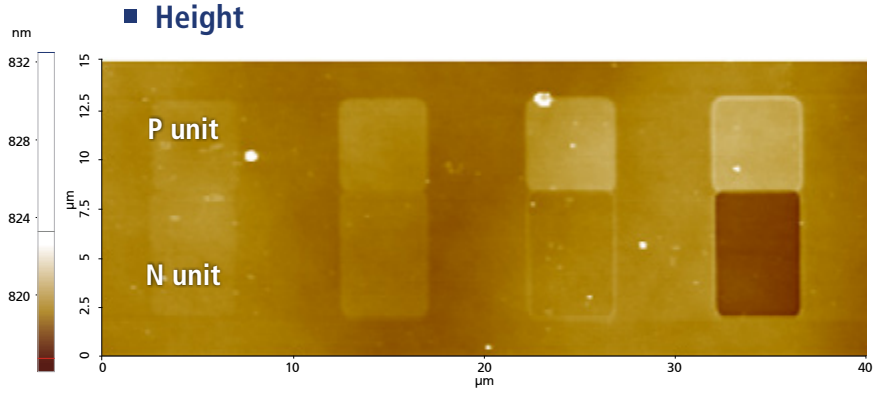
Scanning conditions

- System: FX200
- Scan Size: 500 nm × 500 nm, 200 nm × 200 nm
- Scan Mode: Conductive AFM
- Scan Rate: All 15 Hz
- Cantilever: SPARK 70 Pt (k=2 N/m, f=70 kHz)
- Pixel Size: All 512 × 512

P-N Dopant Sample with Different Concentration

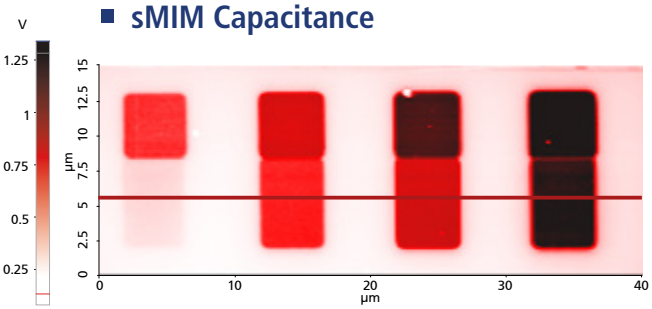
sMIM

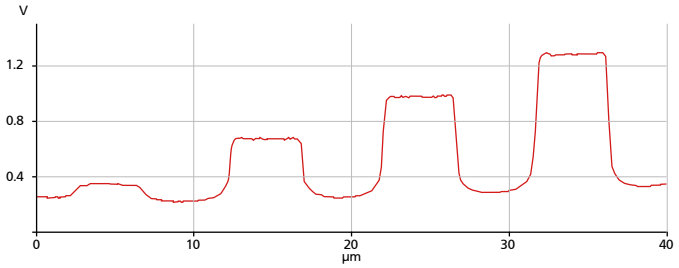
Height



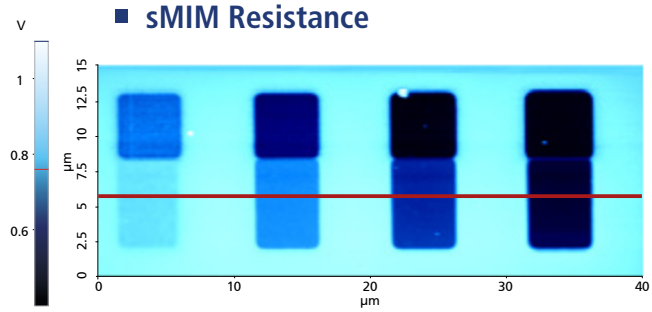
Peak to valley: 15.94 nm

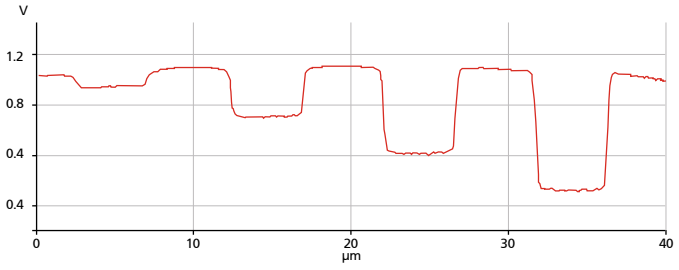
sMIM Capacitance





sMIM Resistance





• Sample courtesy: Dr. Nithi, TMEC, Thailand

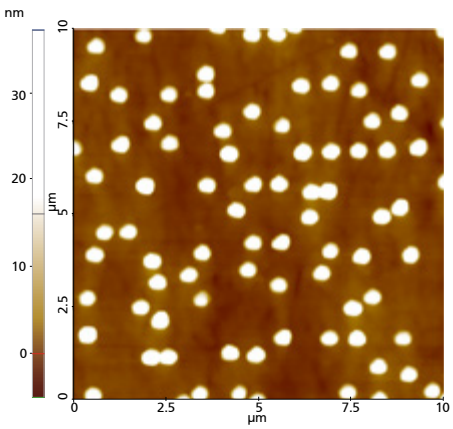
Scanning conditions

- System: NX20
- Scan Size: 40 μm × 15 μm
- Scan Mode: sMIM
- Scan Rate: 0.5 Hz
- Cantilever: sMIM (Long)(k=1 N/m, f=19 kHz)
- Pixel Size: 512 × 512

PMOS and NMOS Plug

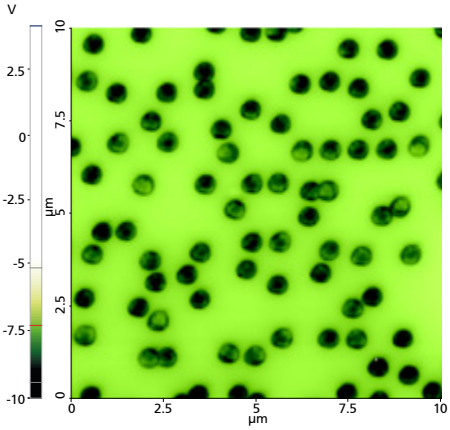
sMIM

Height



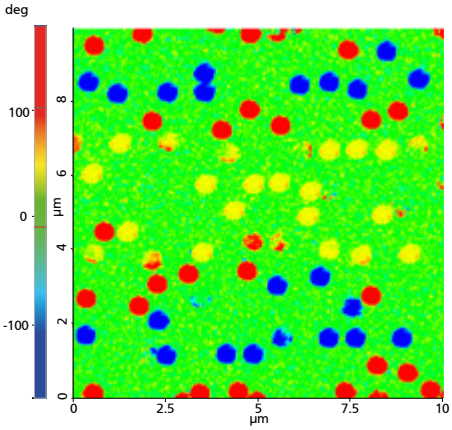
Peak to valley: 42.6 nm

sMIM Capacitance



Peak to valley: 14.1 V

dC/dV Phase



Peak to valley: 345 deg

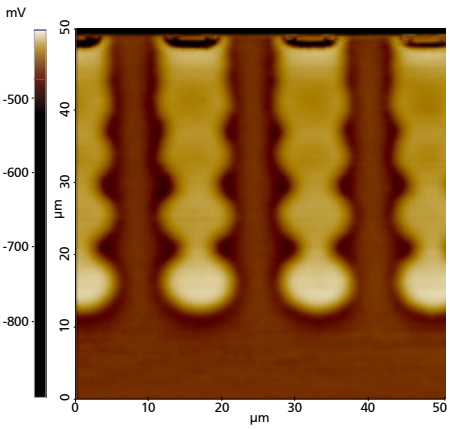
Scanning conditions

- System: NX20
- Scan Size: 10 µm × 10 µm
- Scan Mode: sMIM
- Scan Rate: 1 Hz
- Cantilever: sMIM (Short) (k=8 N/m, f=75 kHz)
- Pixel Size: 512 × 256

MOSFET

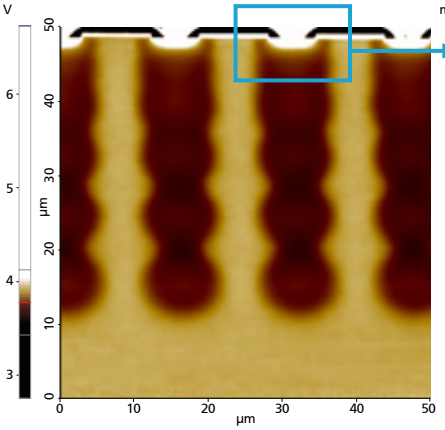
sMIM

sMIM Resistance



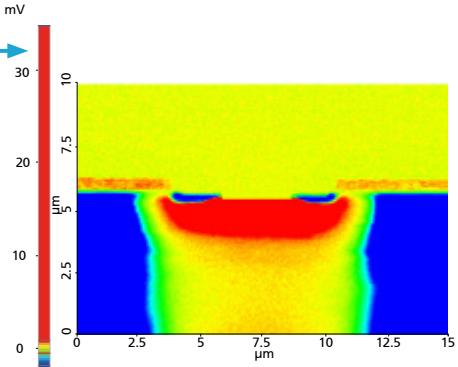
Peak to valley: 0.45 V

sMIM Capacitance



Peak to valley: 4.0 V

Zoom-in dC/dV Quad

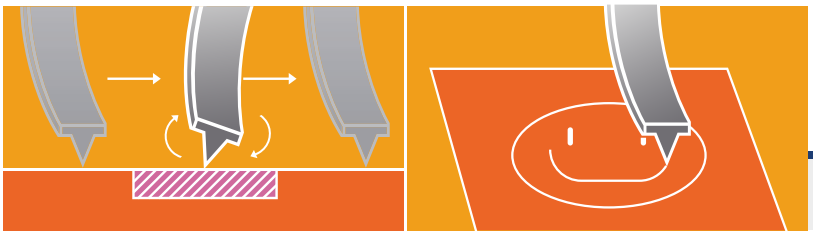


Peak to valley: 40 mV

Scanning conditions

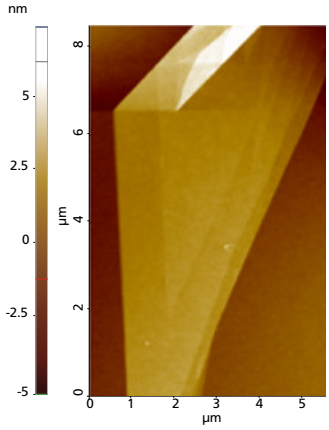
- System: NX20
- Scan Size: 50 µm × 50 µm, 15 µm × 10 µm
- Scan Mode: sMIM
- Scan Rate: All 0.3 Hzz
- Cantilever: sMIM (Short) (k=8 N/m, f=75 kHz)
- Pixel Size: All 512 × 256

Tailored Cutting and Isolation of Graphene Flake



LFM, Lithography

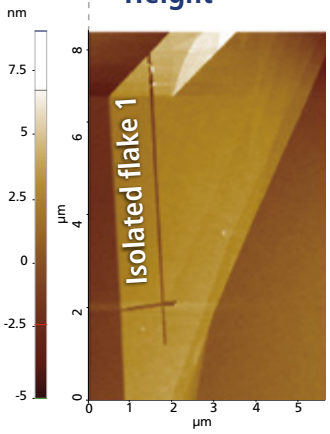
Before Cutting
Height



Peak to valley: 12.62 nm

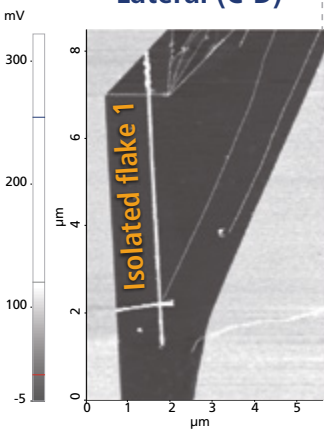
After 1st Cutting

Height



Peak to valley: 14.50 nm

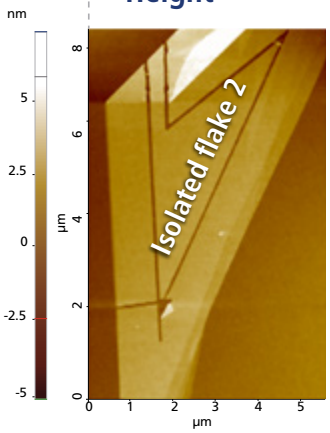
Lateral (C-D)



Peak to valley: 340 mV

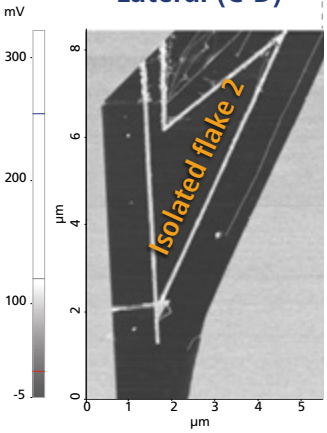
After 2nd Cutting

Height



Peak to valley: 12.58 nm

Lateral (C-D)



Peak to valley: 254 mV

- Electrochemical Cutting and Isolation of Individual Graphene flake on a Si/SiO_2 substrate using local anodic oxidation with AC bias nanolithography.

  Conditions for AC bias Lithography for cutting:

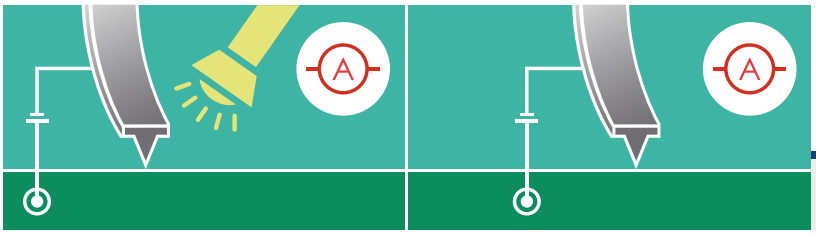
  Tip bias=10 V at 45 kHz,
  Force=250 nN,
  Humidity=70% RH

- Sample courtesy: Sanket Jugade, Prof. Akshay Naik, Centre for Nano Science and Engineering, Indian Institute of Science Bengaluru, India

Scanning conditions

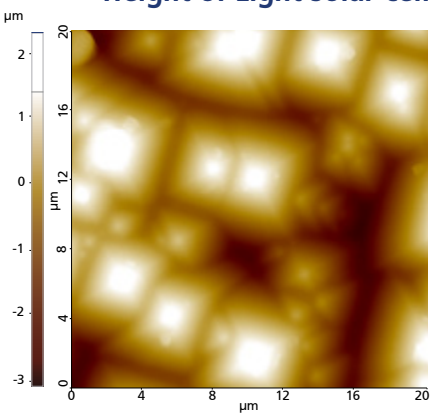
- System: NX20
- Scan Size: All 5.5 µm × 8.5 µm
- Scan Mode: : LFM, Lithography
- Scan Rate: All 0.8 Hz
- Cantilever: ElectriMulti75-G (k=3 N/m, f=75 kHz)
- Pixel Size: All 256 × 256

Solar Cell with Different Anti-Reflection Properties



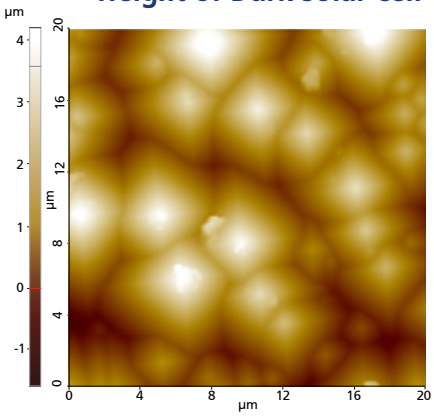
PCM, Conductive AFM

Height of Light solar cell



Peak to valley: 5.52 µm

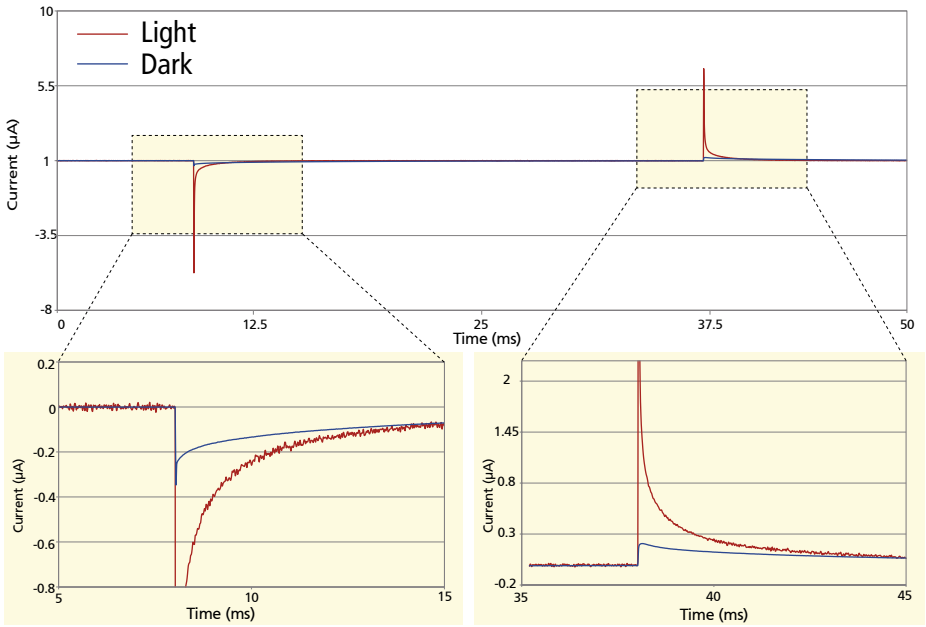
Height of Dark solar cell



Peak to valley: 5.82 µm

- The two solar cell samples with different anti-reflection properties (Light and Dark) show differences in photocurrent characteristics when the extra laser is turned on and off.

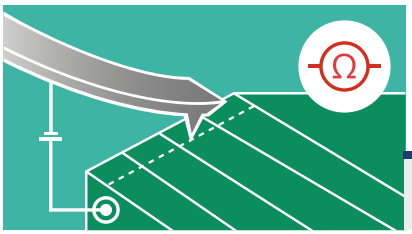
Photo Current Spectroscopy



Scanning conditions

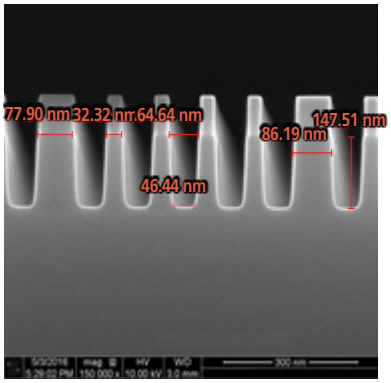
- System: FX40
- Scan Size: All 20 µm × 20 µm
- Scan Mode: PCM, Conductive AFM
- Scan Rate: All 0.25 Hz
- Cantilever: AC160TS (k=26 N/m, f=300 kHz)
- Pixel Size: All 512 × 256

Ge ALE on Patterned Wafer



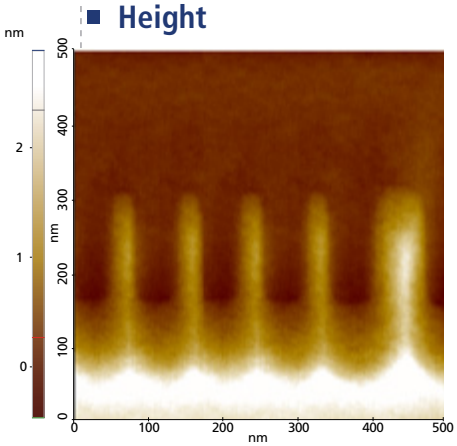
Scanning Spreading Resistance Microscopy (SSRM)

SEM



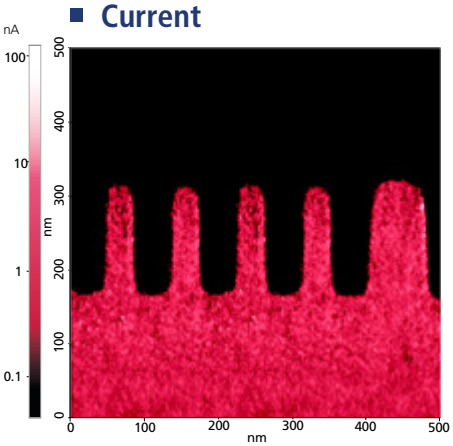
SSRM Measurements

Height



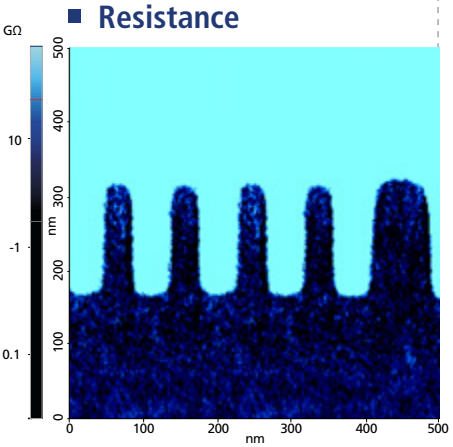
Peak to valley: 3.4 nm

Current



Peak to valley: 118 nA

Resistance



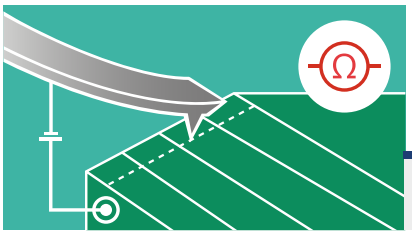
Peak to valley: 73 GΩ

- Ge (Germanium) Atomic Layer Etching (ALE) is a precision etching technique used to pattern germanium on a wafer with atomic level control. It is highly relevant in semiconductor manufacturing, particularly in advanced processes for semiconductor devices such as FinFETs, memristors, and optical devices.

Scanning conditions

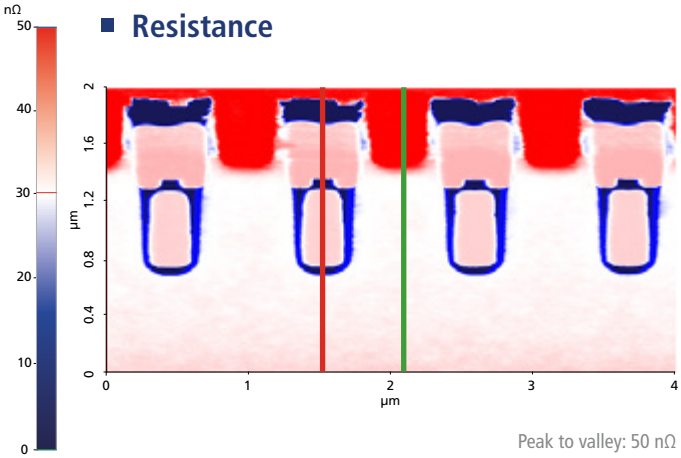
- System: FX200
- Scan Size: 0.5 µm × 0.5 µm
- Scan Mode: SSRM
- Scan Rate: 1 Hz
- Cantilever: CDT-CONTR (k=0.5 N/m, f=20 kHz)
- Pixel Size: 512 × 256

Trench MOSFET



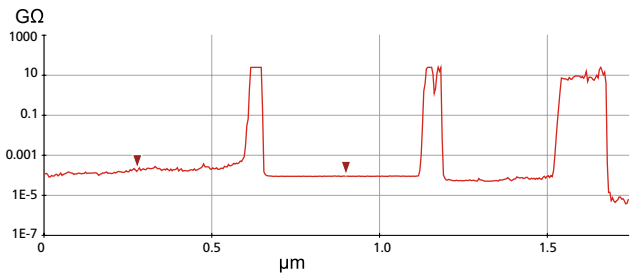
Scanning Spreading Resistance Microscopy (SSRM)

Resistance

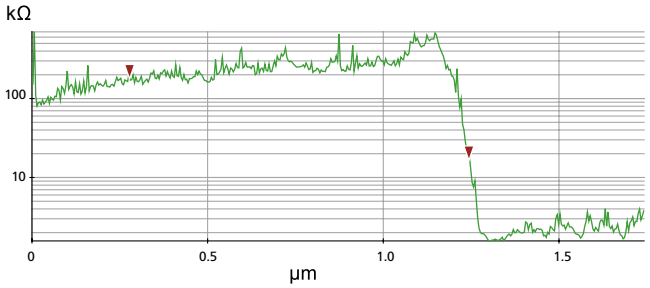


Peak to valley: 50 nΩ

Line profile



Cursor	Left Y (MΩ)	Right Y (MΩ)
Red	412.032	0.125



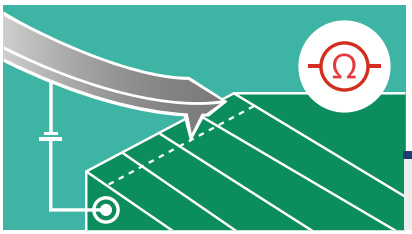
Cursor	Left Y (MΩ)	Right Y (MΩ)
Red	413.231	0.010

- Trench MOSFET resistance analysis is essential for optimizing power efficiency, switching performance, and thermal management, as key resistance components influence conduction losses and device reliability; SSRM enables nanoscale mapping of local conductivity and contact resistance, providing critical insights for performance enhancement and power loss reduction.

Scanning conditions

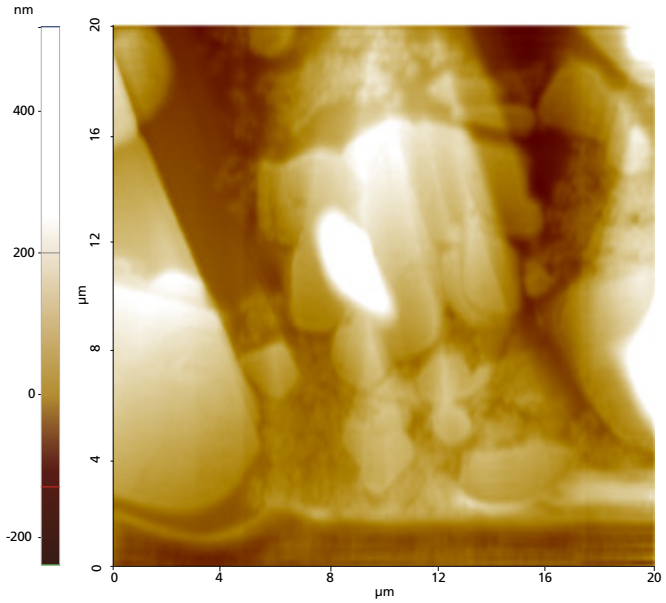
- System: FX200
- Scan Size: 4 µm × 2 µm
- Scan Mode: SSRM
- Scan Rate: 1 Hz
- Cantilever: CDT-NCHR (k=80 N/m, f=400 kHz)
- Pixel Size: 512 × 256

Li-ion Battery on Si Substrate



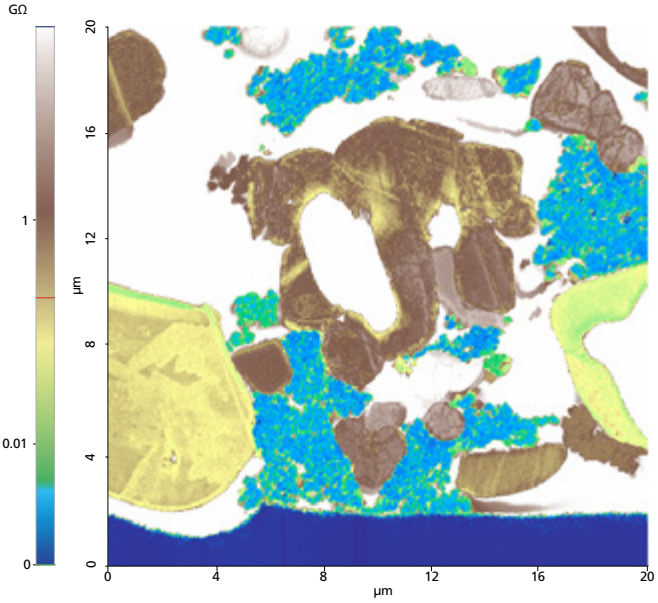
Scanning Spreading Resistance Microscopy (SSRM)

Height



Peak to valley: 768.8 nm

Resistance



Peak to valley: 51.7 GΩ

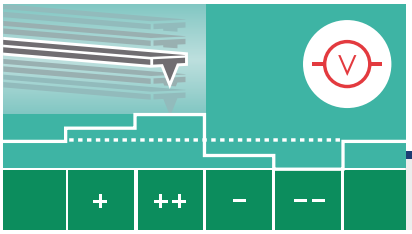
- In a Li-ion battery on a Si substrate, resistance signals indicate charge transport characteristics, electrode/electrolyte interface properties, and potential degradation effects.

  SSRM provides information on local conductivity, lithium distribution, and material heterogeneity, which are critical for performance optimization and failure analysis.

Scanning conditions

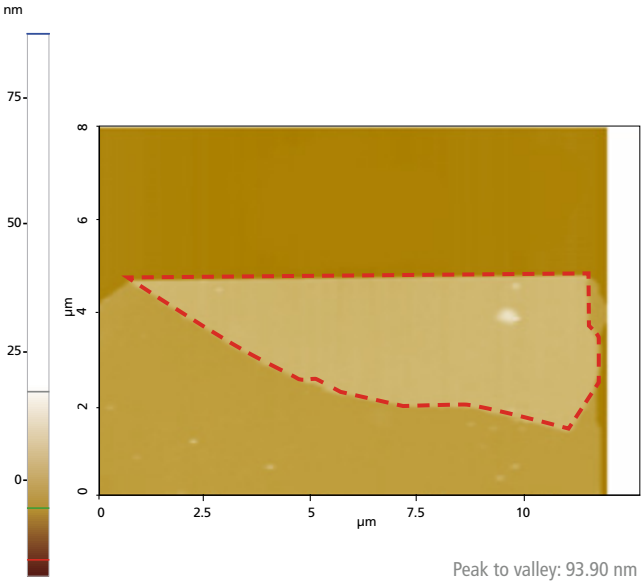
- System: NX-Hivac
- Scan Size: 20 µm × 20 µm
- Scan Mode: SSRM
- Scan Rate: 0.18 Hz
- Cantilever: CDT-NCHR (k=80 N/m, f=400 kHz)
- Pixel Size: 512 × 512

Moiré Patterns on Folded hBN



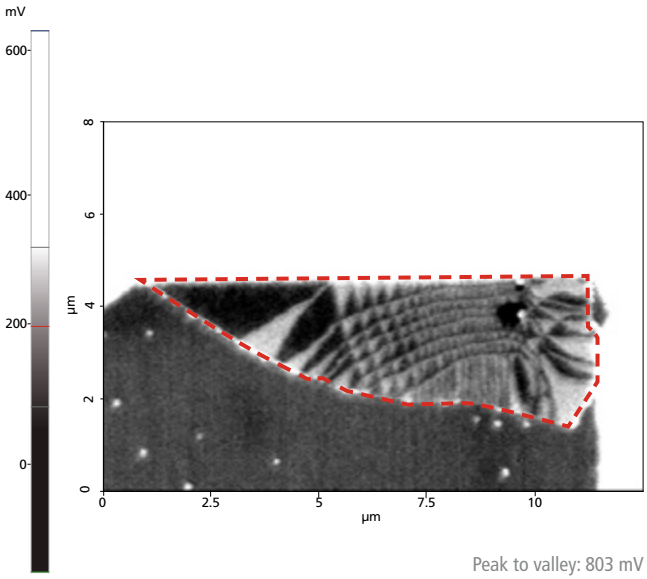
Sideband KPFM

Height



Peak to valley: 93.90 nm

Potential by Sideband KPFM



Peak to valley: 803 mV

- After folding (Red dot area) a single layer of hexagonal boron nitride (hBN), a moiré pattern is observed at the region where the layers meet due to the folding.

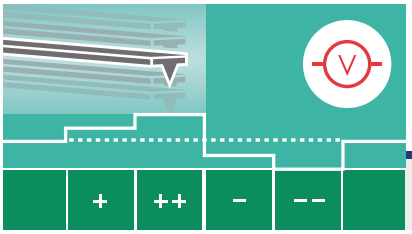
  KPFM can measure the surface potential difference of the moiré pattern, revealing areas of higher or lower potential.

• Sample courtesy: National University of Singapore

Scanning conditions

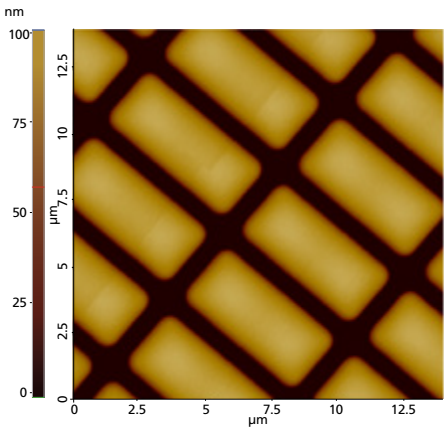
- System: NX10
- Scan Size: 12 µm × 8 µm
- Scan Mode: Sideband KPFM
- Scan Rate: 0.5 Hz
- Cantilever: ElectriMulti75-G (k=3 N/m, f=75 kHz)
- Pixel Size: 256 × 256

Patterned Wafer



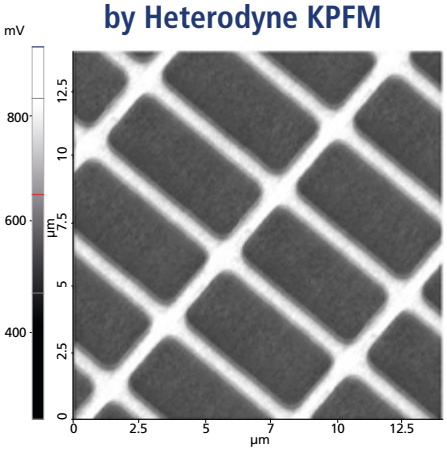
Heterodyne KPFM

Height



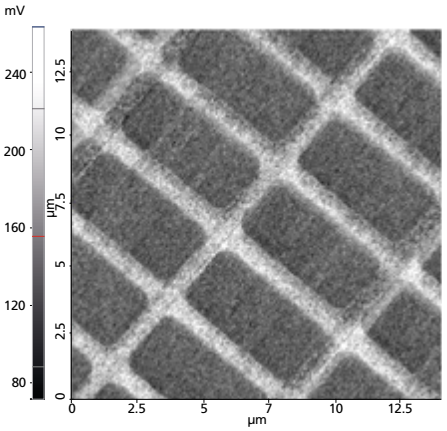
Peak to valley: 101 nm

Potential by Heterodyne KPFM



Peak to valley: 681 mV

Potential by AM KPFM



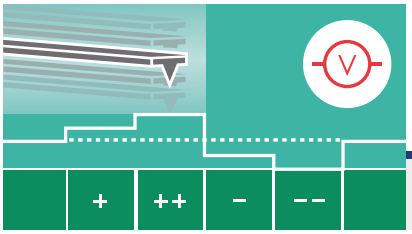
Peak to valley: 192 mV

- Heterodyne KPFM is more sensitive and can provide higher resolution in measuring surface potential, especially in the presence of noise, because it uses a frequency modulation technique to improve signal-to-noise ratio.

Scanning conditions

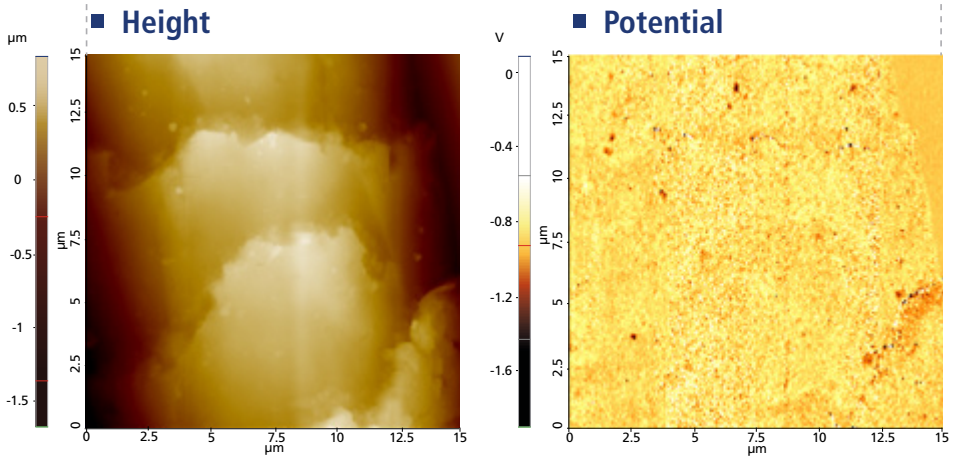
- System: FX200
- Scan Size: All 14 µm × 14 µm
- Scan Mode: Heterodyne KPFM
- Scan Rate: All 0.3 Hz
- Cantilever: NSC14/Cr-Au (k=5 N/m, f=160 kHz)
- Pixel Size: All 512 × 256

Comparison of Hair before and after Treatment

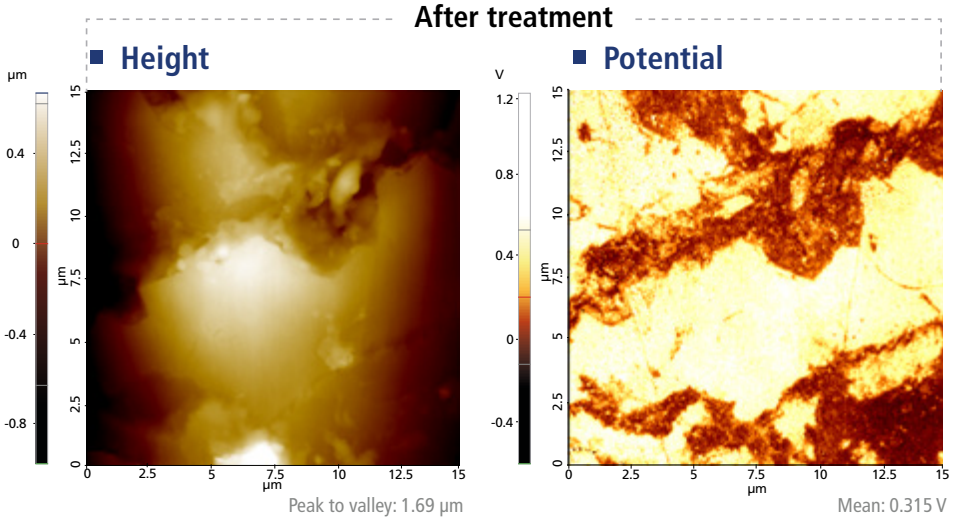


Kelvin Probe Force Microscopy (KPFM)

Before treatment



After treatment



- Human hair has a slightly negative charge on its surface due to the presence of functional groups (like carboxyl and amine groups) on the hair's cuticle. Chemical treatments introduce new functional groups that either increase or neutralize the surface charge.

Scanning conditions

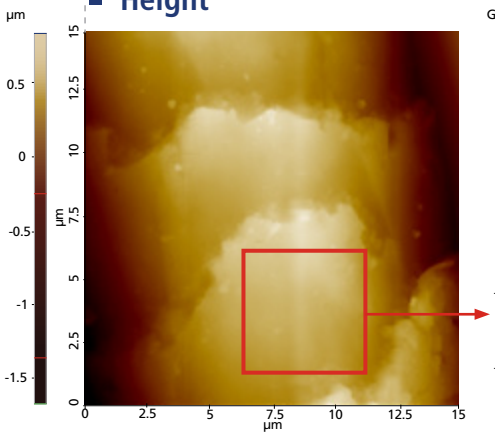
- System: FX200
- Scan Size: All 15 µm × 15 µm
- Scan Mode: KPFM
- Scan Rate: All 0.3 Hz
- Cantilever: NSC36/Cr-Au C (k=0.6 N/m, f=65 kHz)
- Pixel Size: All 256 × 512

Comparison of Hair before and after Treatment



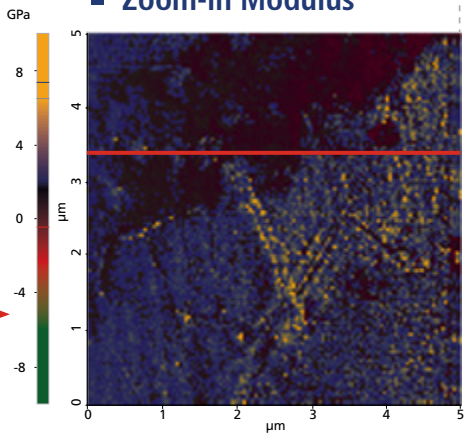
Before treatment

Height



Peak to valley: 2.56 µm

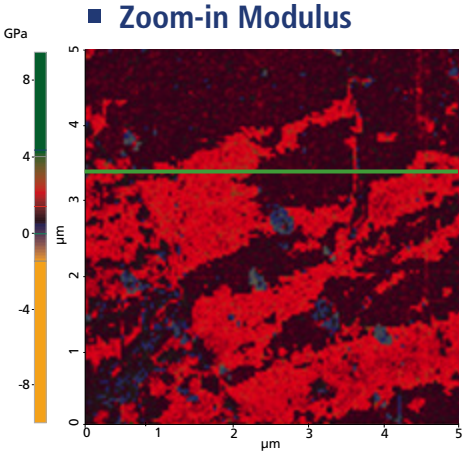
Zoom-in Modulus



Mean: 2.06 GPa

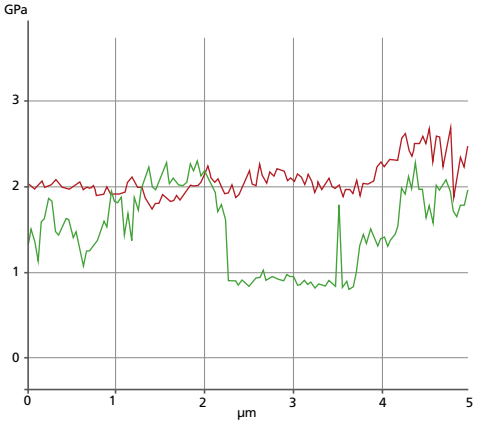
After treatment

Zoom-in Modulus



Mean: 1.41 GPa

Line Profile

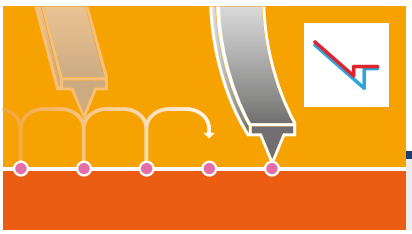


- Modulus analysis of chemically treated hair reveals a reduction in stiffness, as the degradation of keratin structure and loss of intermolecular cross-links lower the mechanical integrity compared to untreated hair.

Scanning conditions

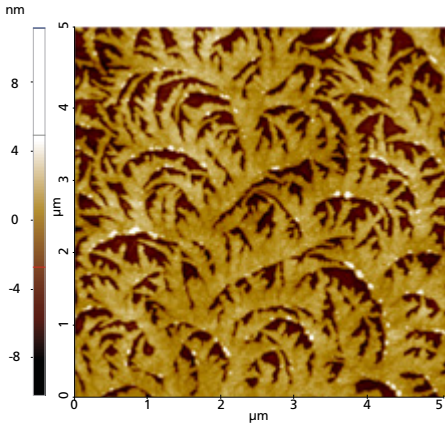
- System: FX200
- Scan Size: 15 µm × 15 µm, 5 µm × 5 µm
- Scan Mode: PinPoint nanomechanical
- Scan Rate: All 0.3 Hz
- Cantilever: AC240TS (k=2 N/m, f=70 kHz)
- Pixel Size: 256 × 512, 128 × 128

Polyethylene Terephthalate (PET)



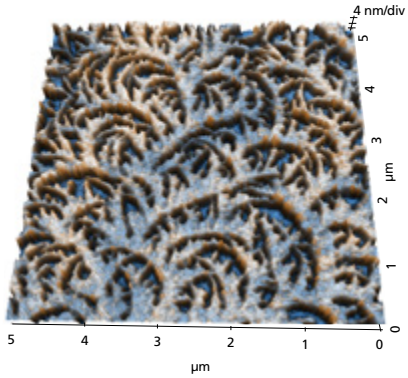
PinPoint nanomechanical

Height



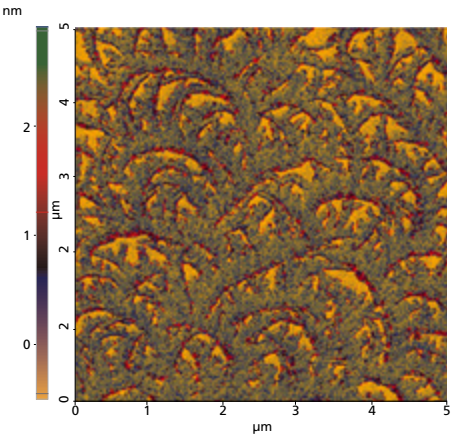
Peak to valley: 15.20 nm

3D Image



X:Y:Z scale = 1:1:50

Deformation



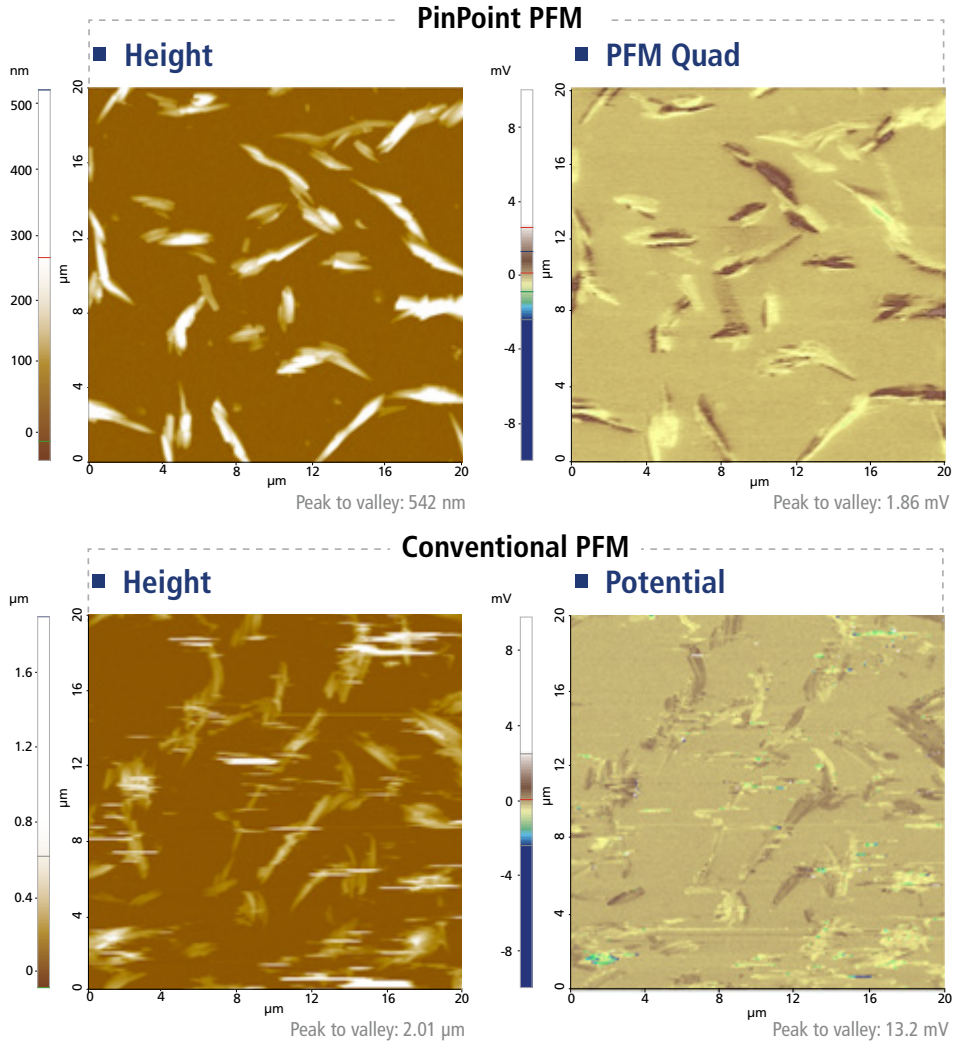
Peak to valley: 2.73 nm

Scanning conditions

- System: NX20
- Scan Size: 5 µm × 5 µm
- Scan Mode: PinPoint nanomechanical
- Scan Rate: 0.17 Hz
- Cantilever: AC160TS (k=26 N/m, f=300 kHz)
- Pixel Size: 256 × 256

Organic Molecules

PinPoint PFM



- Compared to the conventional PFM (raster scan), the PinPoint PFM is particularly useful when measuring soft materials.

  PinPoint scan helps prevent lateral scratches caused by the tip, enabling more accurate measurements.

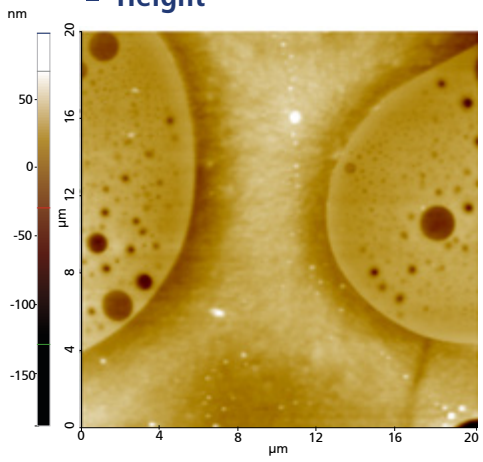
Scanning conditions

- System: NX10
- Scan Size: All 20 µm × 20 µm
- Scan Mode: PinPoint PFM
- Scan Rate: All 0.2 Hz
- Cantilever: PPP-EFM (k=2.8 N/m, f=75 kHz)
- Pixel Size: All 256 × 256

PS-LDPE

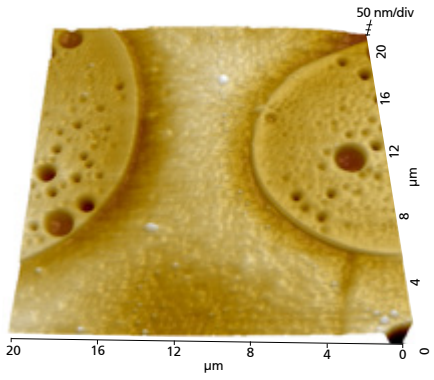
Fast PinPoint

Height



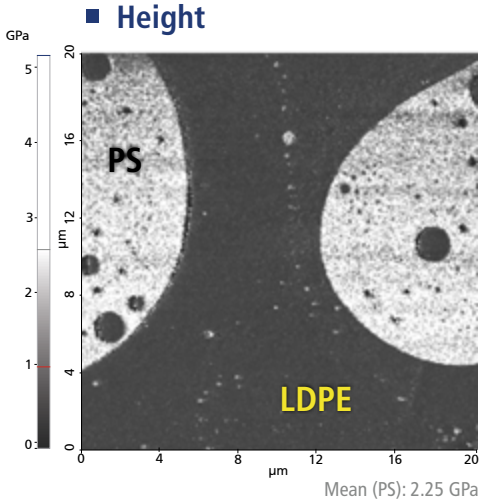
Peak to valley: 289 nm

3D Image



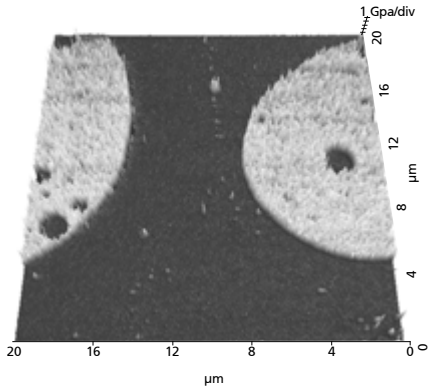
X:Y:Z scale = 1:1:10

Height



Mean (PS): 2.25 GPa
Mean (LDPE): 0.316 GPa

Modulus 3D Image



X:Y:Z scale = 1:1:0.1

- Fast PinPoint can measure mechanical properties such as modulus and adhesion force along with height information within a few minutes.

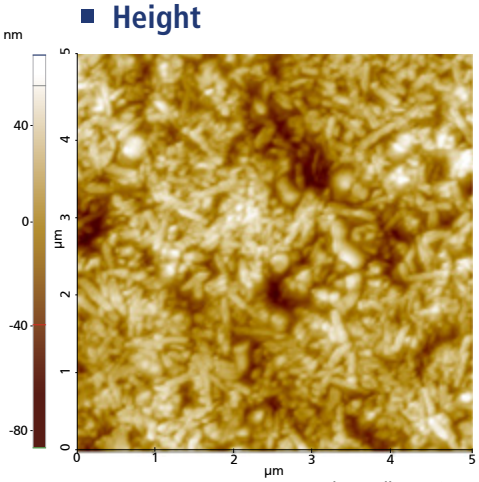
Scanning conditions

- System: NX10
- Scan Size: 20 µm × 20 µm
- Scan Mode: Fast PinPoint
- Scan Rate: 1 Hz
- Cantilever: SCOUT 150 (k=18 N/m, f=150 kHz)
- Pixel Size: 256 × 256

Floppy Disk

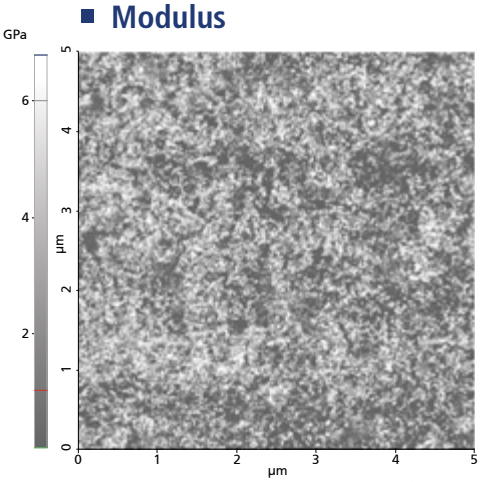
Fast PinPoint

Height



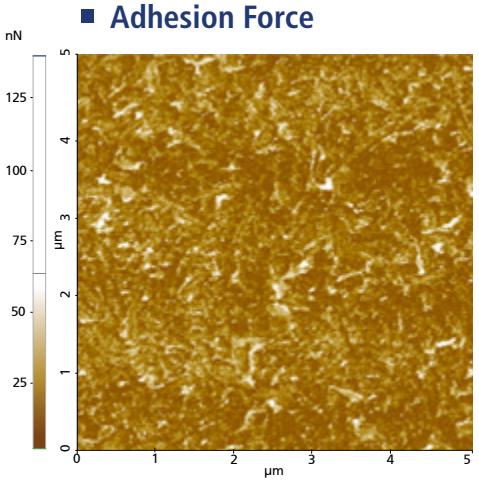
Peak to valley: 153 nm

Modulus



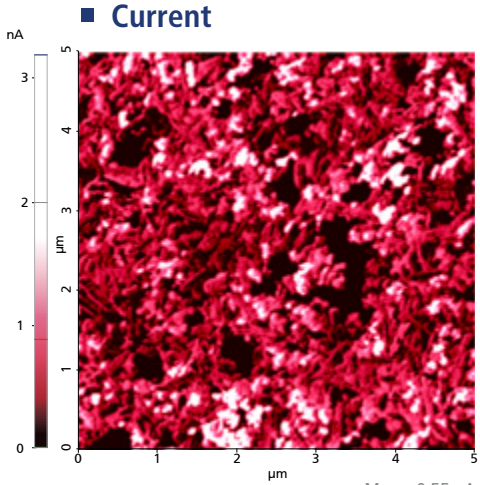
Mean: 2.14 GPa

Adhesion Force



Mean: 19.75 nN

Current



Mean: 0.55 nA

- Fast PinPoint offers the advantage of speed while also being combined with contact-based AFM modes, allowing for the simultaneous acquisition of multiple types of information (Height, mechanical properties, and current).

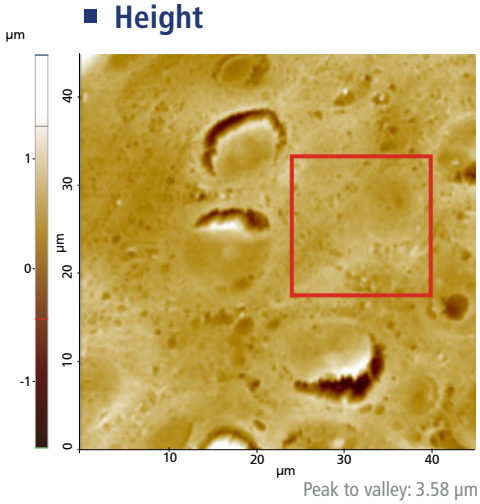
Scanning conditions

- System: NX10
- Scan Size: 5 µm × 5 µm
- Scan Mode: Fast PinPoint
- Scan Rate: 1 Hz
- Cantilever: CDT-NCHR (k=80 N/m, f=400 kHz)
- Pixel Size: 256 × 256

Tissue

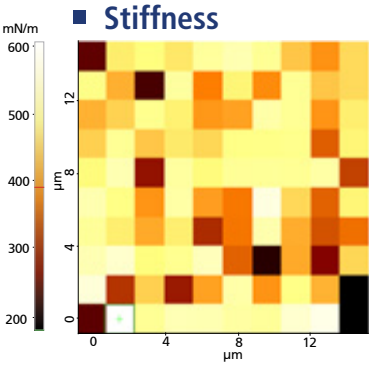
Force Spectroscopy Mapping

Height

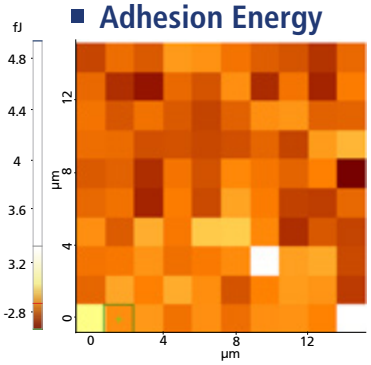


Peak to valley: 3.58 µm

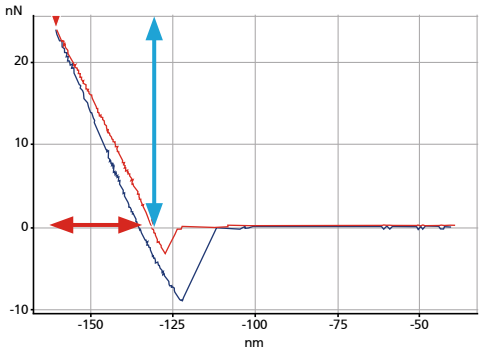
Stiffness



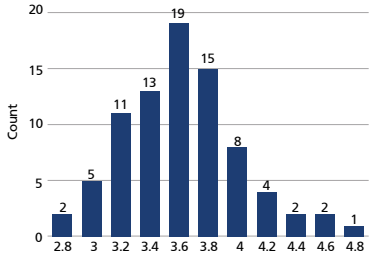
Adhesion Energy



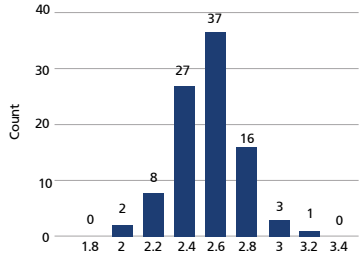
FD Curve



Stiffness (mN/m)



Adhesion Energy (fJ)

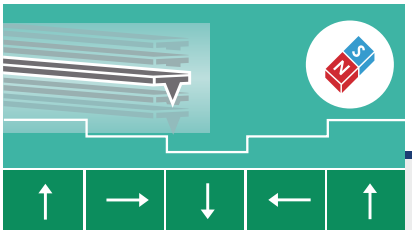


- Force: 23.7 nN
  Deformation: 29.4 nm
  Young's Modulus: 26.6 MPa

Scanning conditions

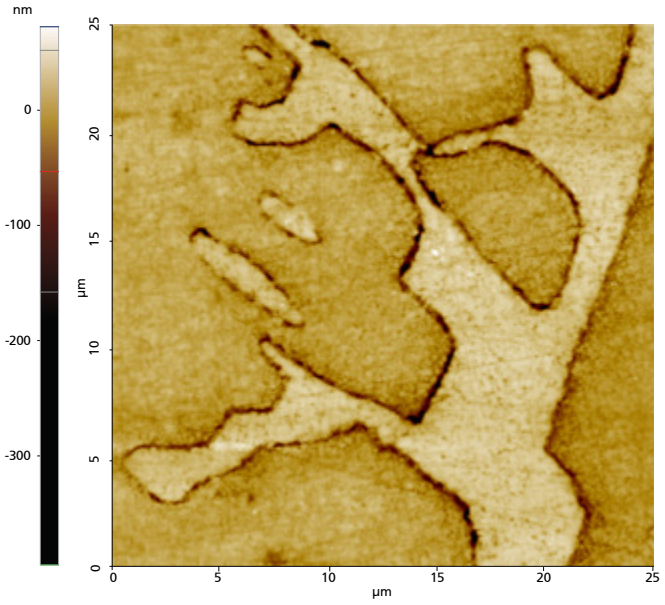
- System: FX200
- Scan Size: 16 µm × 16 µm
- Scan Mode: Force Spectroscopy Mapping
- Cantilever: NSC36 C (k=0.6 N/m, f=65 kHz)
- Pixel Size: 10 × 10

2205 Stainless Steel



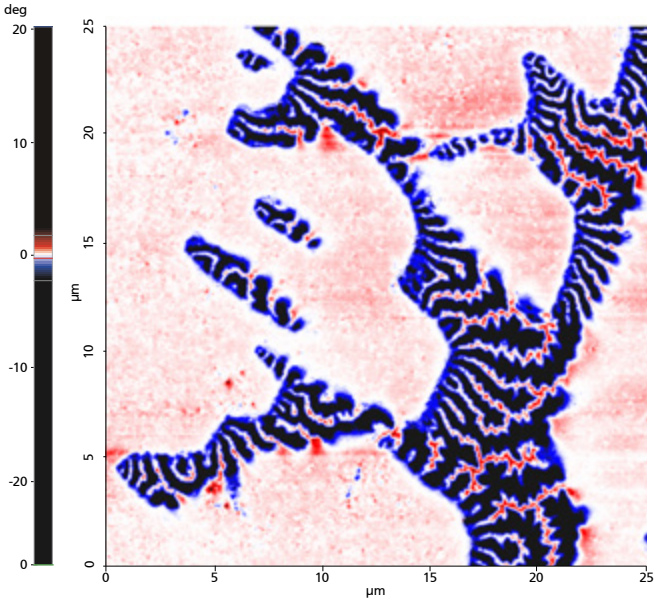
Magnetic Force Microscopy (MFM)

Height



Peak to valley: 471 nm

MFM Phase



Lift Height: 20 nm

- 2205 stainless steel has a balanced microstructure of both austenite and ferrite phases. Unlike fully austenitic stainless steels, which are non-magnetic, it contains a significant amount of ferrite making it partially magnetic.

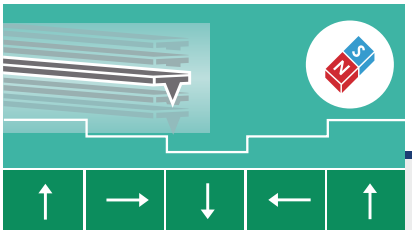
  MFM can be used to analyze 2205 stainless steel by mapping its magnetic domains, revealing variations in ferrite distribution and phase transformation effects

• Sample courtesy: Joel Moreno, UGTO, Francisco Flores, IFUAP, México

Scanning conditions

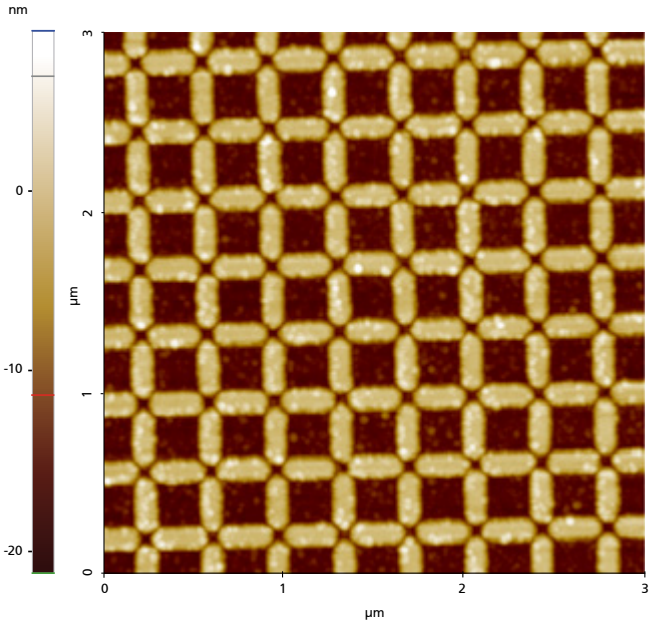
- System: NX10
- Scan Size: 25 µm × 25 µm
- Scan Mode: MFM
- Scan Rate: 0.2 Hz
- Cantilever: PPP-MFMR (k=2.8 N/m, f=75 kHz)
- Pixel Size: 1024 × 1024

Artificial Spin Ice Lattices (B)



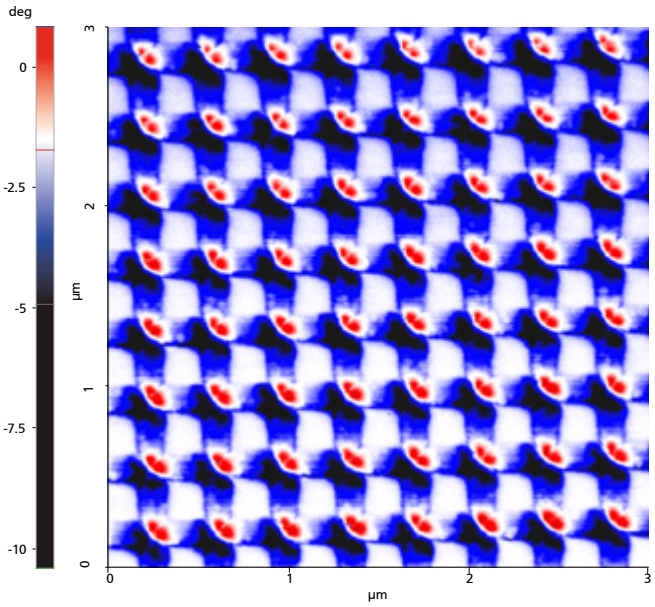
Magnetic Force Microscopy (MFM)

Height



Peak to valley: 37.82 nm

MFM Phase



Lift Height: 20 nm

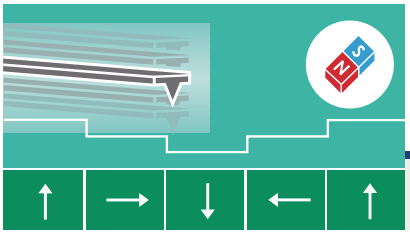
- Artificial Spin Ice Lattices can be altered by modifying their geometry, material properties, or external conditions, enabling control over their magnetic behavior and emergent phenomena.

• Sample courtesy: Benjamin Jungjfleisch, University of Delaware, US

Scanning conditions

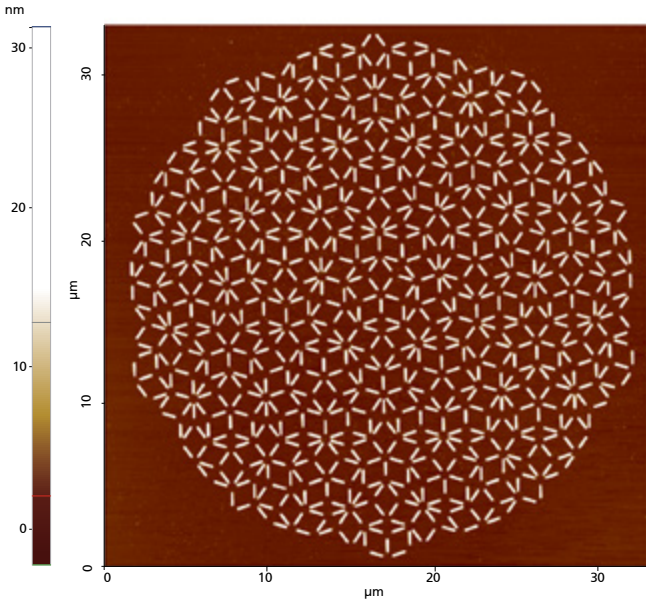
- System: NX10
- Scan Size: 3 µm × 3 µm
- Scan Mode: MFM
- Scan Rate: 0.5 Hz
- Cantilever: PPP-MFMR (k=2.8 N/m, f=75 kHz)
- Pixel Size: 512 × 512

Artificial Spin Ice Lattices (H)



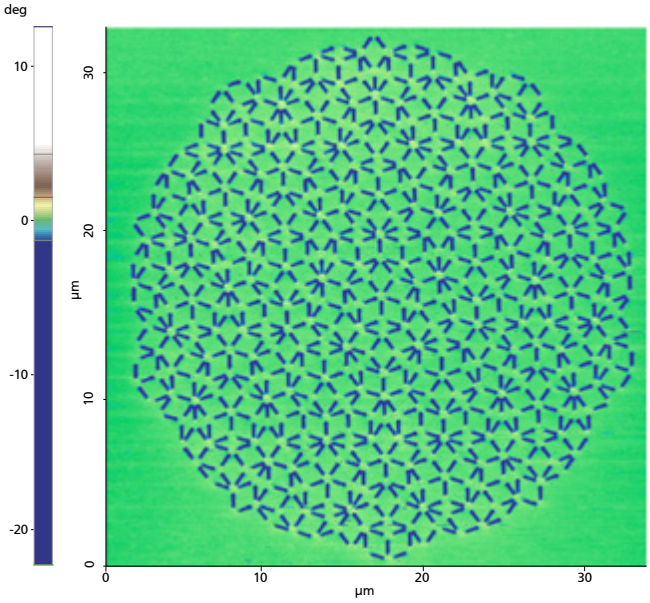
Magnetic Force Microscopy (MFM)

Height



Peak to valley: 33.54 nm

MFM Phase



Lift Height: 20 nm

- Artificial Spin Ice Lattices are engineered arrays of nanomagnetic elements systematically arranged to exhibit intriguing phenomena, such as emergent magnetic monopoles and magnetic phase transitions.

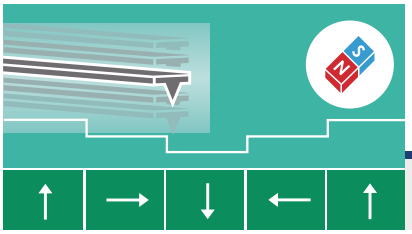
  Studying Artificial Spin Ice Lattices with MFM enables high-resolution, non-destructive visualization of nanoscale magnetic configurations.

• Sample courtesy: Benjamin Jungjfleisch, University of Delaware, US

Scanning conditions

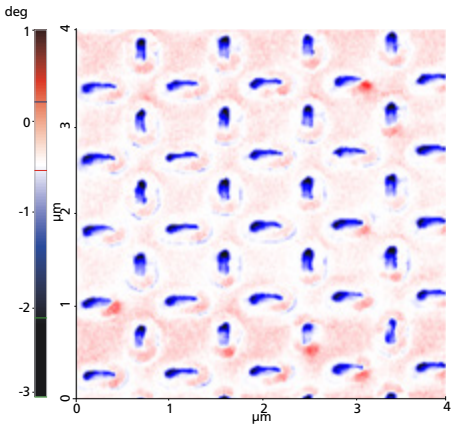
- System: NX10
- Scan Size: 33 µm × 33 µm
- Scan Mode: MFM
- Scan Rate: 0.1 Hz
- Cantilever: PPP-MFMR (k=2.8 N/m, f=75 kHz)
- Pixel Size: 1024 × 1024

Magnetic Material Patterned Wafer

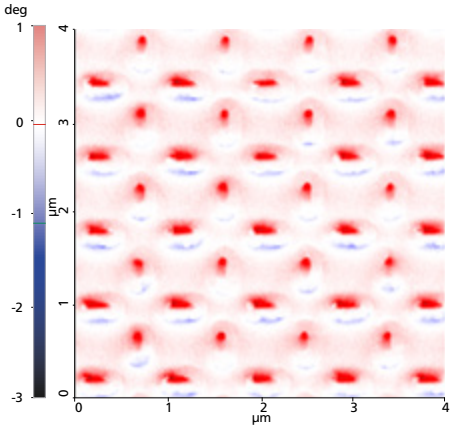


MFM, Field-Switchable MFG

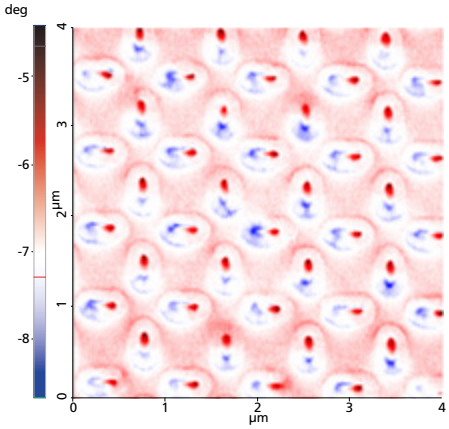
■ MFM Phase @ 0 G



■ @ In-plane 2,000 G



■ @ Out-of-plane 2,000 G



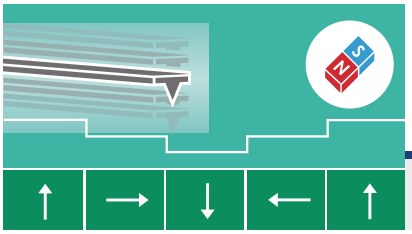
■ The magnetic property was changed depending on the magnitude and direction of the external magnetic field.

• Sample courtesy: Benjamin Jungjfleisch, University of Delaware, US

Scanning conditions

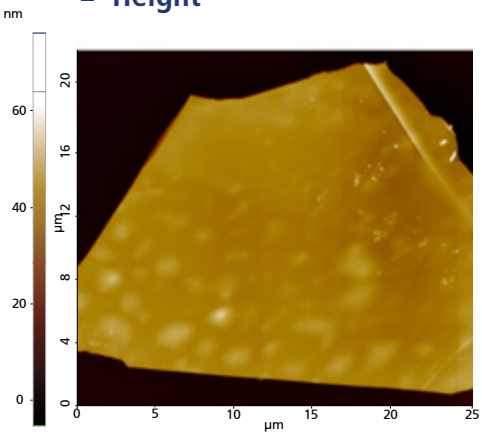
- System: NX10
- Scan Size: All 4 µm × 4 µm
- Scan Mode: MFM, Field-Switchable MFG
- Scan Rate: All 0.3 Hz
- Cantilever: PPP-MFMR (k=2.8 N/m, f=75 kHz)
- Pixel Size: All 512 × 256

Pt/Co hBN

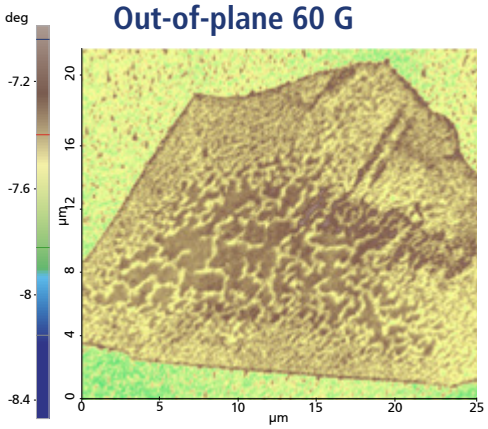


MFM, Field-Switchable MFG

Height

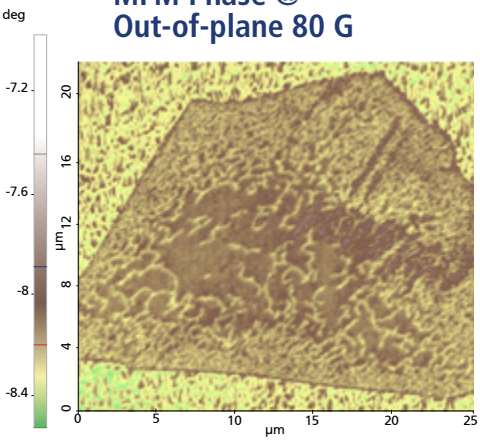


MFM Phase @ Out-of-plane 60 G

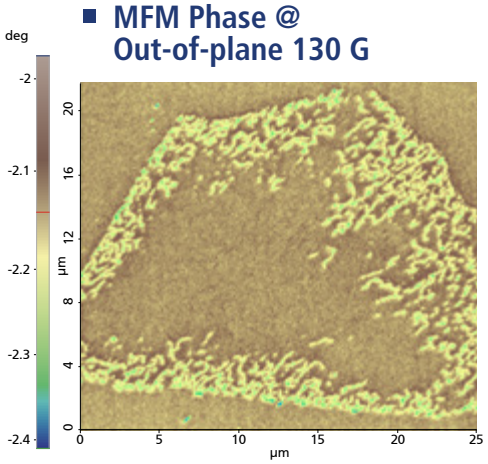


Peak to valley: 83.43 nm

MFM Phase @ Out-of-plane 80 G



MFM Phase @ Out-of-plane 130 G



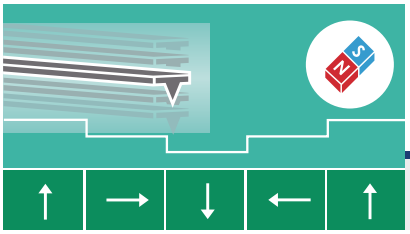
- When an external magnetic field is applied using a Magnetic Force Generator, the behavior of Pt/Co hBN varies depending on the field strength.

• Image courtesy: Laboratoire de physique des solides, France
El-Kerdi et. al.,(2023) Evidence of strong dzyaloshinskii–moriya interaction at the cobalt/hexagonal boron nitride interface. Nano Letters, 23(8), 3202-3208.

Scanning conditions

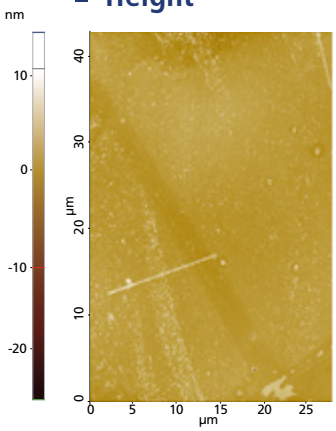
- System: NX10
- Scan Size: All 25 µm × 25 µm
- Scan Mode: MFM, Field-Switchable MFG
- Scan Rate: All 0.5 Hz
- Cantilever: PPP-MFMR (k=2.8 N/m, f=75 kHz)
- Pixel Size: All 512 × 512

Permalloy



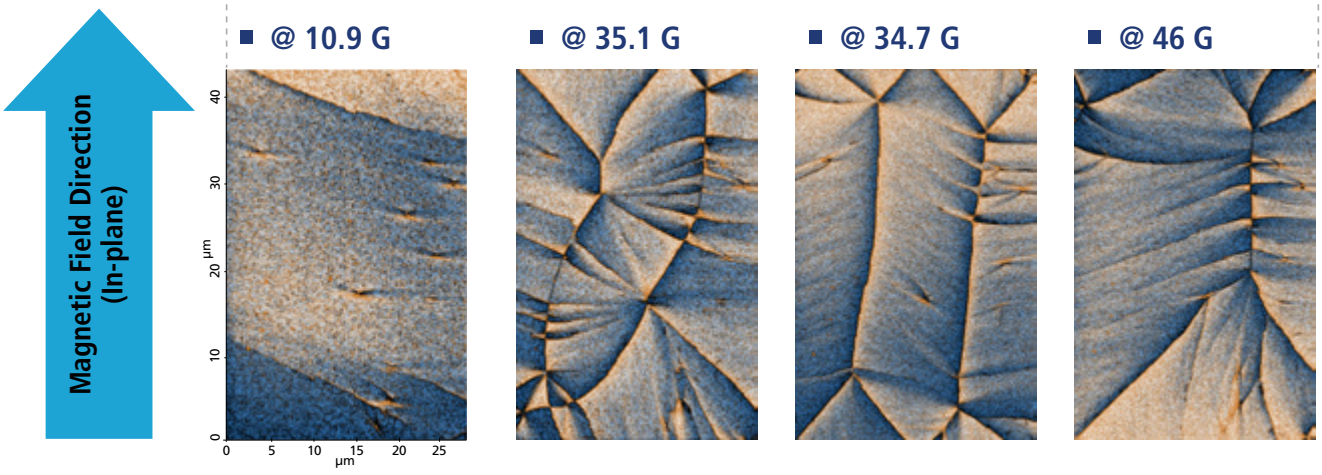
MFM, Field-Switchable MFG

Height



Peak to valley: 35.5 nm

MFM Phase with Field-Switchable MFG

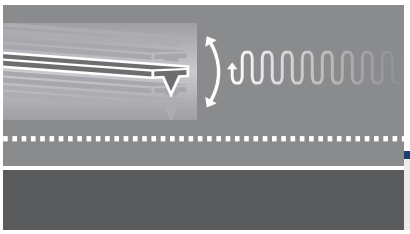


- MFM with Field-Switchable Magnetic Field Generator (MFG) provides precise control of magnetic field with switchable functionality, making it useful in applications that involve nanomaterials, magnetic manipulation, and sensing technologies.

Scanning conditions

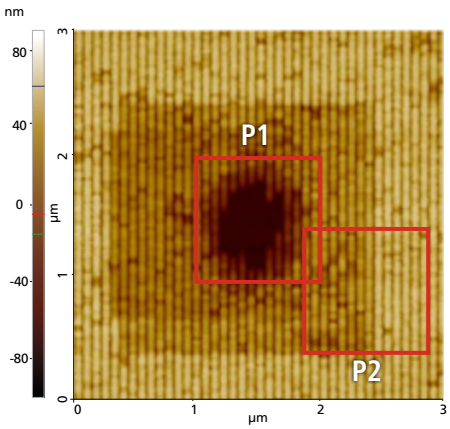
- System: NX10
- Scan Size: All 28 µm × 43 µm
- Scan Mode: MFM, Field-Switchable MFG
- Scan Rate: All 0.5 Hz
- Cantilever: PPP-MFMR (k=2.8 N/m, f=75 kHz)
- Pixel Size: All 1024 × 512

e-Beam Damage on ArF PR

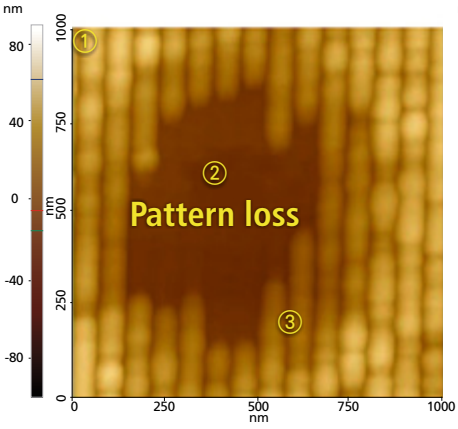


Non-contact

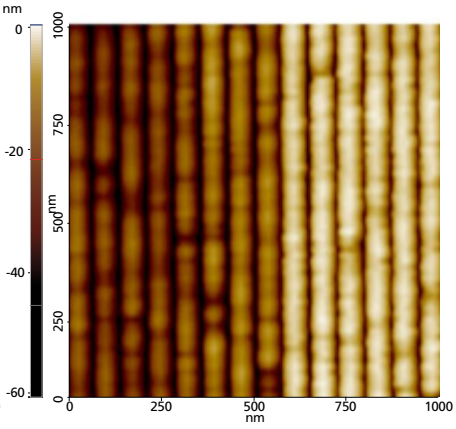
■ Height



■ Height of P1



■ Height of P2



- The next slide shows the PiFM spectrum measured on ① Normal PR pattern / ② Defect (Pattern loss) / ③ Edge of PR pattern.

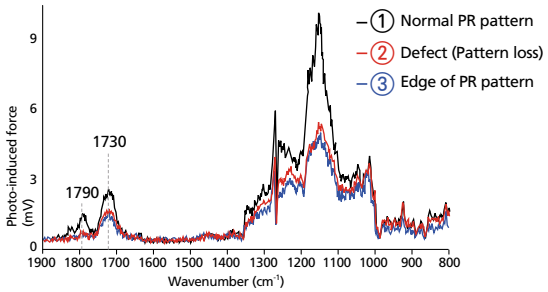
Scanning conditions

- System: FX200 IR
- Scan Size: 3 μm × 3 μm, 1 μm × 1 μm
- Scan Mode: Non-contact
- Scan Rate: All 1 Hz
- Cantilever: NCHPt (k=42 N/m, f=330 kHz)
- Pixel Size: All 512 × 256

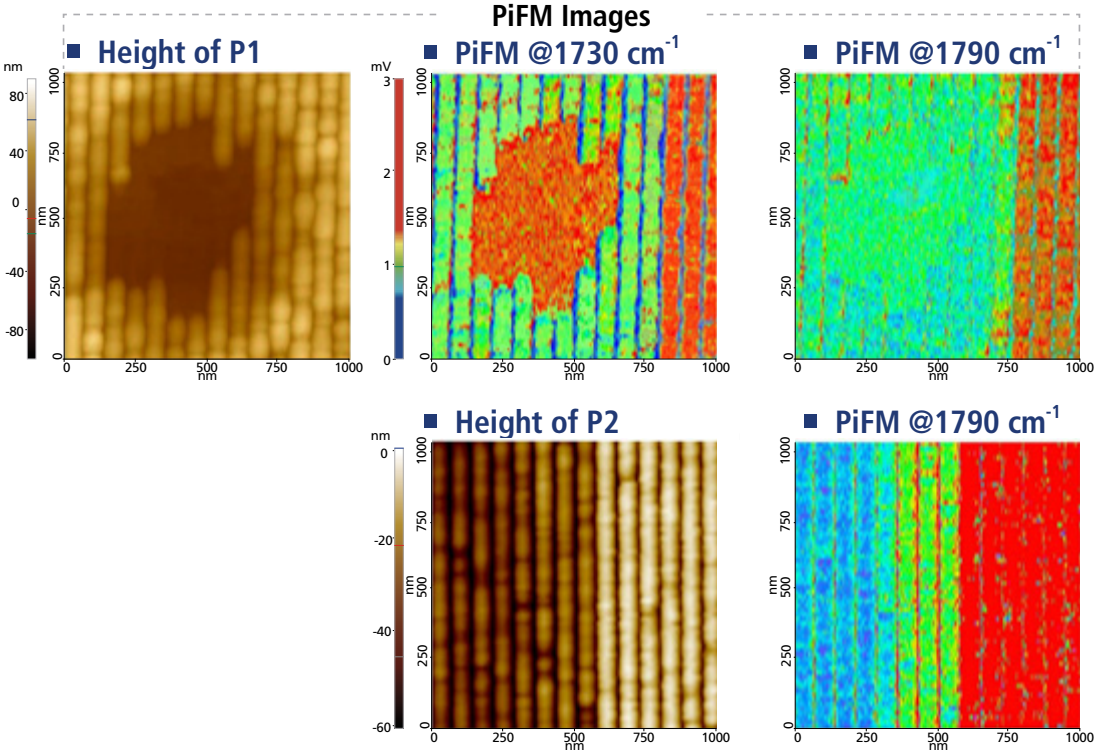
e-Beam Damage on ArF PR

PiFM

PiFM Spectrum



PiFM Images



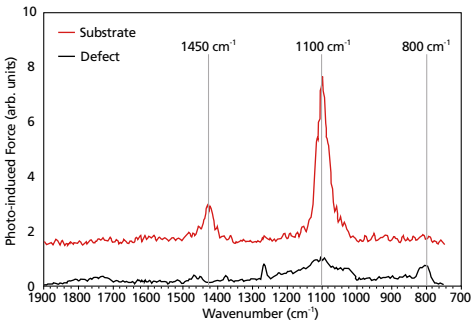
- In the PiFM spectrum, distinctive peaks were observed at 1730 cm^{-1} and 1790 cm^{-1}. These peaks are related to lactone (cyclic carboxylic esters) and the etching rate of the photoresist for ArF laser lithography. The image on the right shows the results based on the PiFM spectrum, where the wavelengths at 1730 cm^{-1} and 1790 cm^{-1} were strategically chosen for the analysis.

Scanning conditions

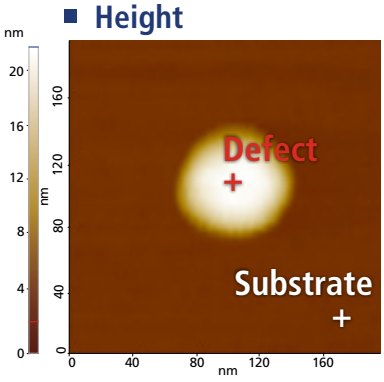
Defect

PiFM

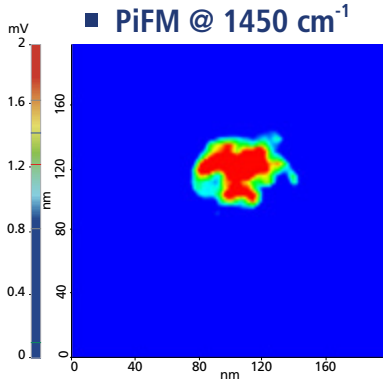
PiFM Spectrum



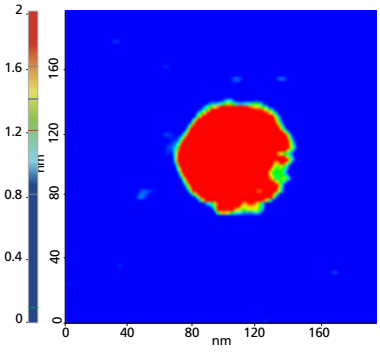
Height



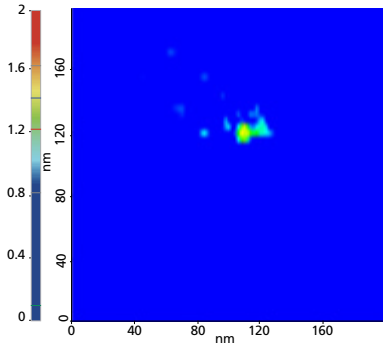
PiFM @ 1450 cm^{-1}



PiFM @ 1100 cm^{-1}



PiFM @ 800 cm^{-1}



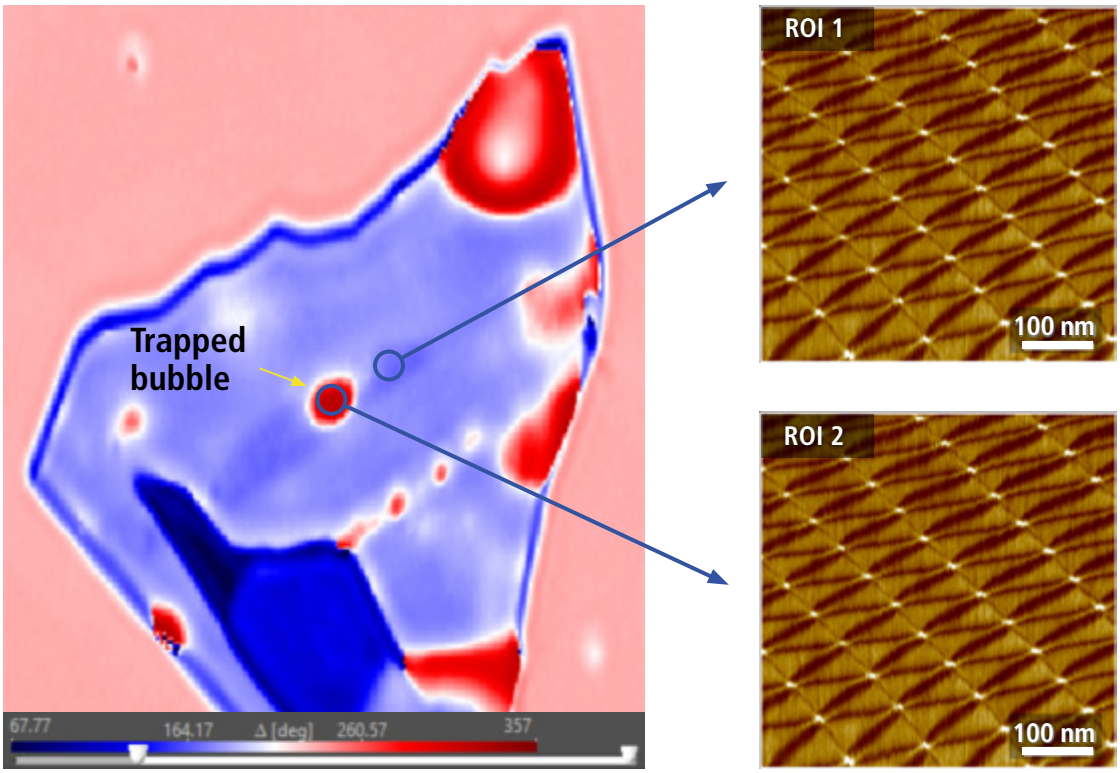
Scanning conditions

- System: FX200 IR
- Scan Size: All 0.2 µm × 0.2 µm
- Scan Mode: PiFM
- Scan Rate: All 1 Hz
- Cantilever: NCHPt (k=42 N/m, f=330 kHz)
- Pixel Size: All 256 × 256

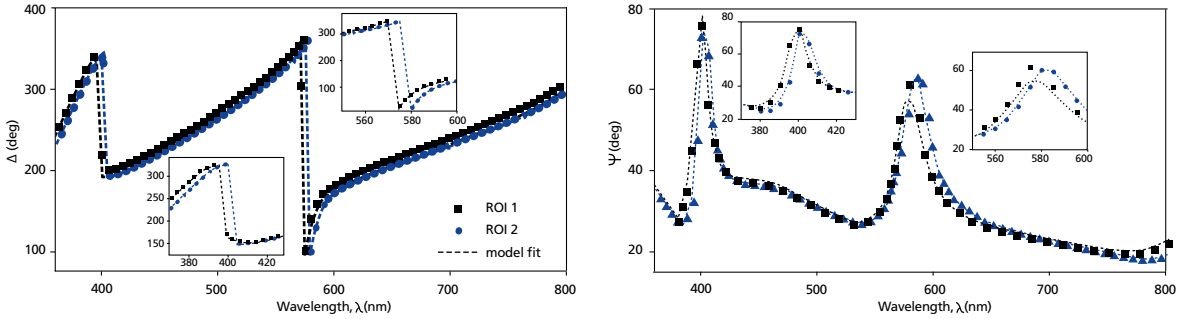
Trapped Bubble in Twisted Bilayer Graphene on hBN

■ ISE; ΔMap at 400 nm

■ C-AFM; Current Image



■ ISE; Δ, Ψ changes due to trapped bubble

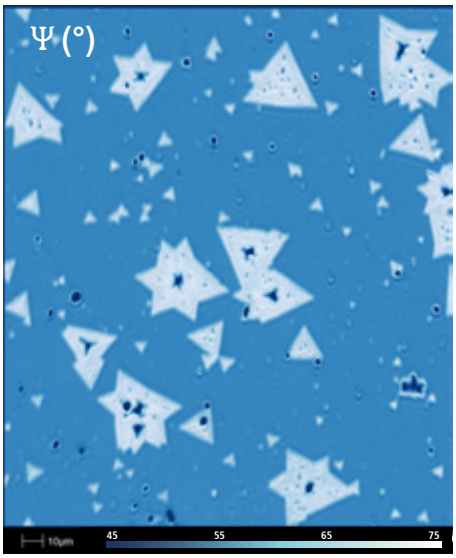


• More information: https://www.parksystems.com/en/learning-center/lc-detail.appnote_97

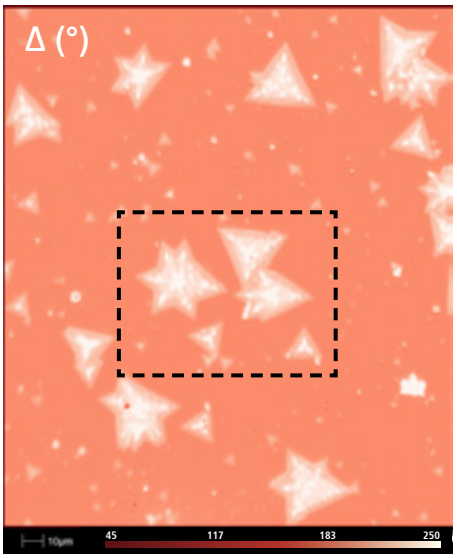
Measurement conditions

$MoSe_2$-WSe_2 Lateral Heterostructure

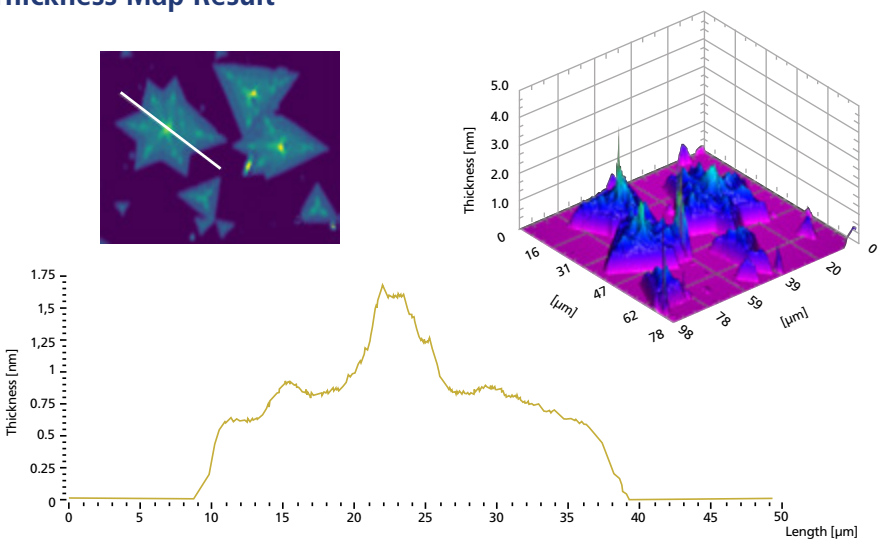
Psi Map



Delta Map



Thickness Map Result



- Optical properties and thickness measurement results of laterally grown $MoSe_2$-WSe_2 heterostructure obtained using Imaging Spectroscopic Ellipsometer.

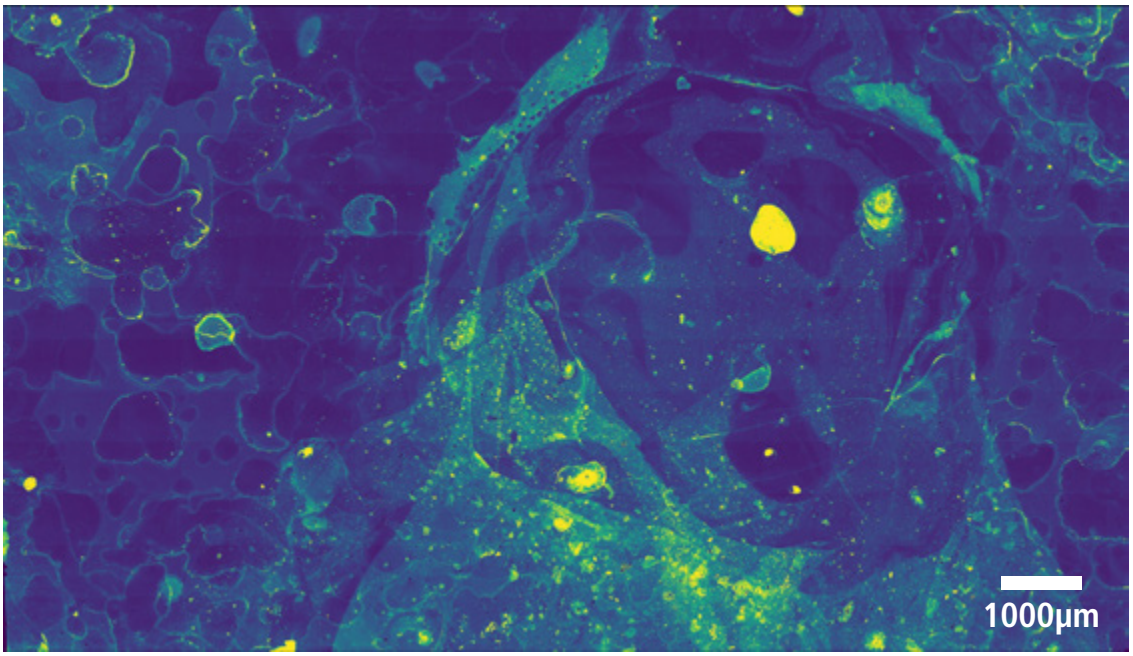
• Sample courtesy: Prof. Kiriya (Department of Basic Science, Tokyo univ.) and Prof. Miyata (Department of Physics, Tokyo Metropolitan univ.)

Measurement conditions

- System: EP4
- Wavelength: 490 nm
- AOI: 50 °
- Objective Lens: 20× Nikon

Residuals on Si Wafer after Water Cleaning Process

Stitched Ellipsometric Contrast Micrograph (ECM)



- A clear image of residuals on Si after a water cleaning process.

  The thickness range of residual films are below 15 nm.

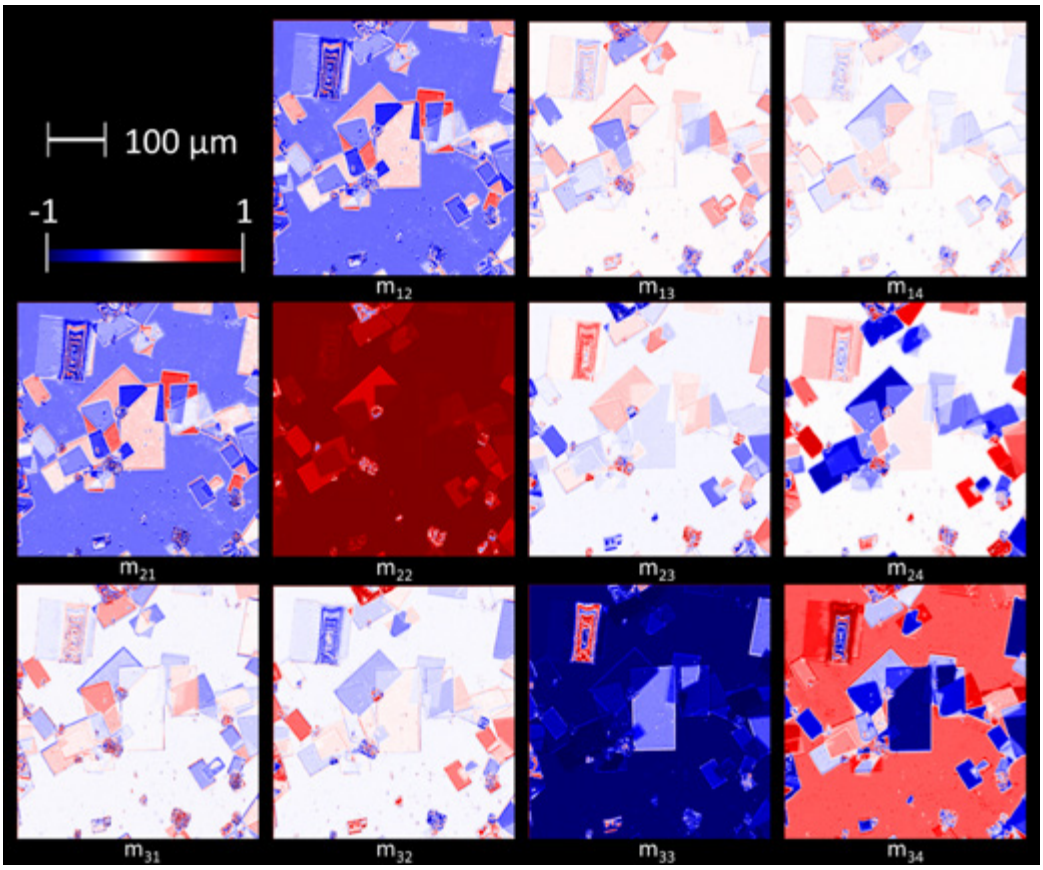
  ISE provides this stitched ECM (Ellipsometric Contrast Micrograph) map with a lateral size of 20 mm × 10 mm within 3 minutes.

Measurement conditions

- System: SIMoN
- Wavelength: 500 nm
- AOI: 45 °
- Objective Lens: 5× Nikon

Anisotropic Organic Crystals

Mueller Matrix Map



- Uric Acid on Si/SiO_2.

  Microscopic organic crystal.

  Different polarization states depending on the optical anisotropy and crystal orientation are observed with high lateral resolution by Imaging Mueller Matrix.

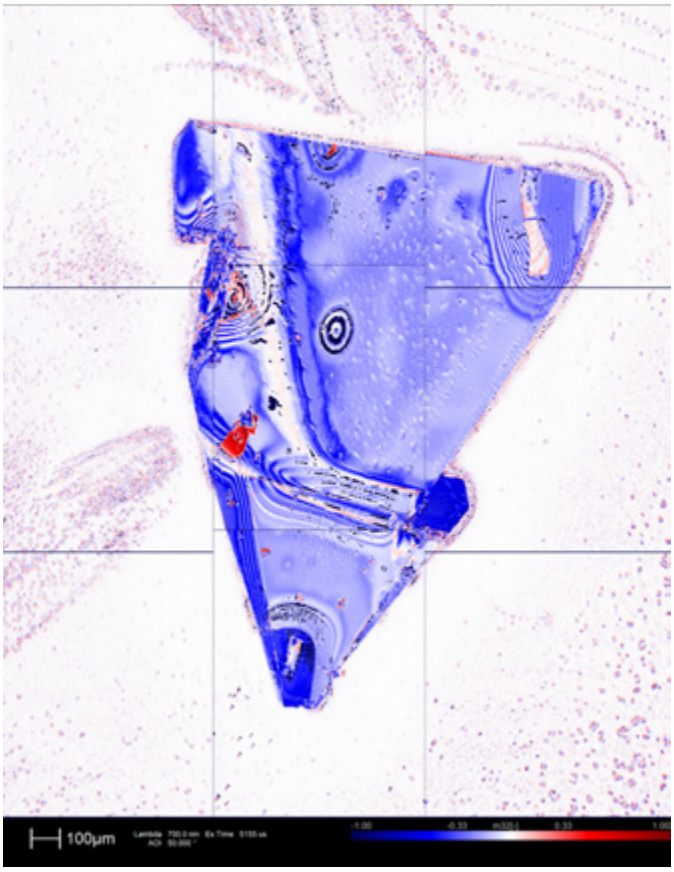
• Sample courtesy: Dan Oron, Weizmann Institute of Science, Rehovot, Israel

Measurement conditions

- System: EP4
- Wavelength: 400 nm
- AOI: 45 °
- Objective Lens: 10× Nikon

Anisotropic Organic Crystals

Stitched Map of the Müller Matrix Element m_{32}



- Uric Acid Derivative on Si/SiO_2.

  Different polarization states depending on the optical anisotropy are measured for a larger microscopic organic crystal.

  By stitching together microscopic maps of the elements of the Müller matrix, an imaging ellipsometer can be used to image all the variations of the entire crystal.

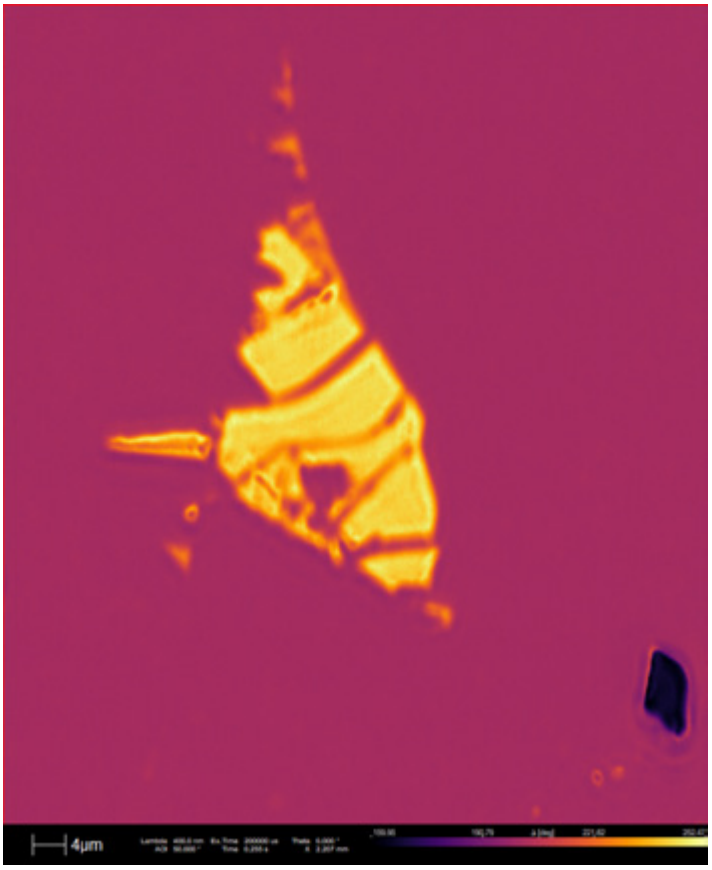
• Sample courtesy: Dan Oron, Weizmann Institute of Science, Rehovot, Israel

Measurement conditions

- System: EP4
- Wavelength: 400 nm
- AOI: 45 °
- Objective Lens: 5× Nikon

Exfoliated Molybdenum (IV) Telluride

Delta Map



- Microcrystal of exfoliated Molybdenum (IV) telluride.

  Only ISE provides microscopic maps of the ellipsometric angles Delta and Psi with a lateral resolution down to 1 µm, enabling precise measurement and analysis of the optical properties of exfoliated 2D Materials – even on different micro crystal substructures like terrace.

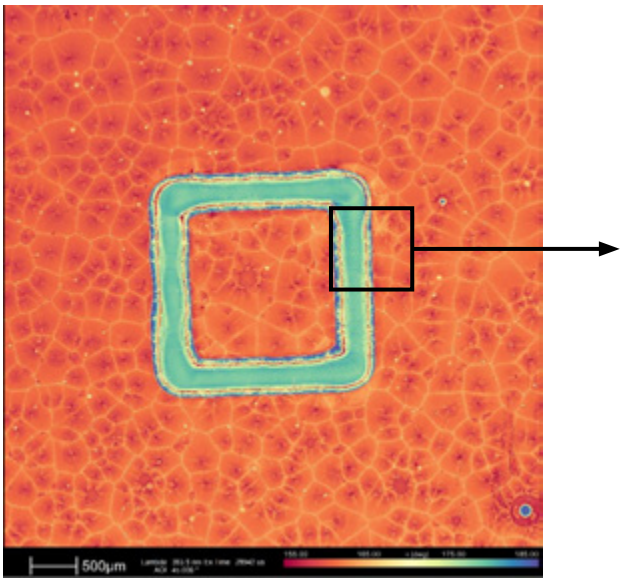
• Sample courtesy: Dr. Janis Köster, Materialwissenschaftliche Elektronenmikroskopie, Universität Ulm

Measurement conditions

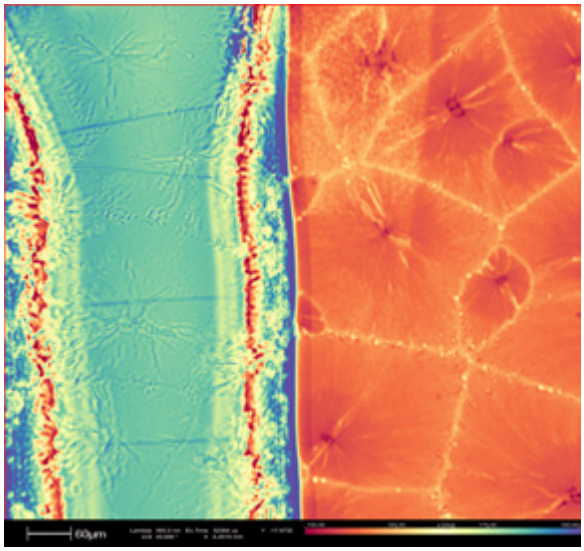
- System: EP4
- Wavelength: 400 nm
- AOI: 50 °
- Objective Lens: 50× Nikon

Lanthanum Nickel Oxide Layers

Delta Map



Zoom-in Delta Map



- Electrically conductive lanthanum nickel oxide layers.

  Applied the 5× objective lens resulting in a lateral resolution of 4 µm.

  A complete image size of 6 mm × 6 mm (Left) with one detailed image from the stitch super image displayed (Right).

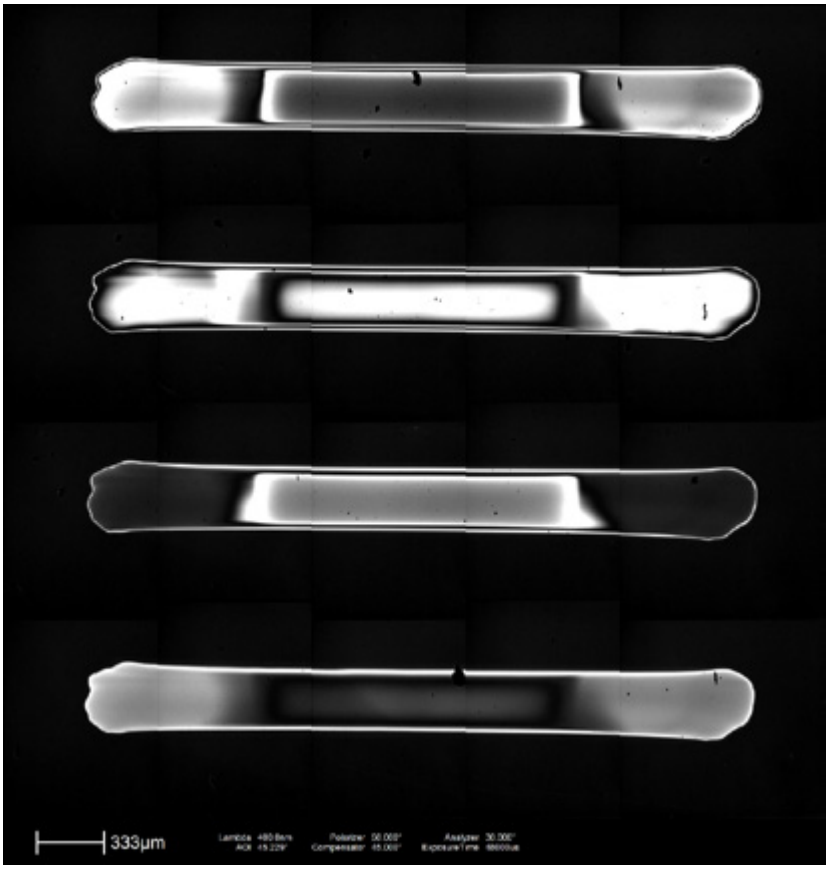
• Sample courtesy: Samuel Moritz Fink, Thin Film Processing, Fraunhofer ILT, Aachen, Germany

Measurement conditions

- System: EP4
- Wavelength: 393.5 nm
- AOI: 45 °
- Objective Lens: 5× Nikon

Printed ALD TiO_2 Structures

Stitched Ellipsometric Contrast Micrograph (ECM)



- TiO_2 strips, ALD printed on Si/SiO_2 (ATLANT 3D's DALP® technology).

  Ellipsometric contrast enable the fast inspection of printed ALD structures – even down to one printing cycle.

  Due to the visualization and the highest sensitivity of the measurements in nulling mode, imaging ellipsometry is the method of choice for the rapid characterization of µ-DALP structures.

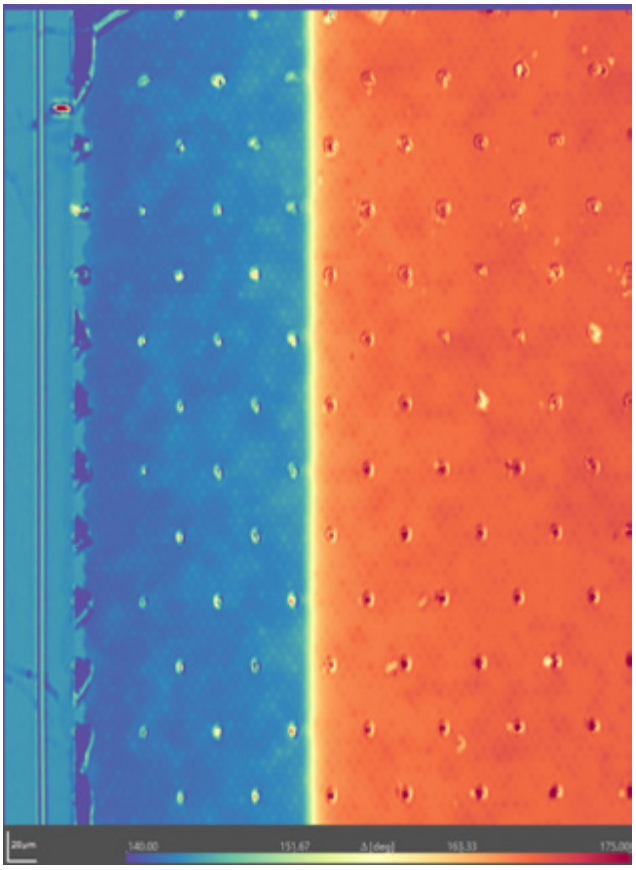
• Sample courtesy: Ivan Kundrata, Mira Baraket, Benjamin Borie, Maksym Plakhotnyuk, ATLAND 3D Nanosystems, Taastrup, Dänemark,

Measurement conditions

- System: SIMoN
- Wavelength: 400 nm
- AOI: 45 °
- Objective Lens: 5× Nikon

20 nm Al_2O_3 Coated LHAR Chip

Delta Map



- ALD coated Al_2O_3 into a horizontal high aspect ratio structure (LHAR Chip from Chipmetrics).

  Ellipsometric contrast and Delta map shows clearly the penetration depth of ALD deposited film with 1 µm lateral resolution.

  The combination of LHAR Chips and precise ISE measurement enables prediction of film deposition inside channel holes such as in 3D NAND and DRAM..

- Sample courtesy: Chipmetrics Finnland

Measurement conditions

- System: EP4
- Wavelength: 365 nm
- AOI: 55 °
- Objective Lens: 10× Nikon

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Park Systems provides a range of popular AFMs for general research and industrial applications. Designed to be extremely versatile while still providing the accuracy and functionality necessary to do high quality work, our line of general AFMs offer researchers and engineers alike the ability to get extremely accurate results quickly and easily.



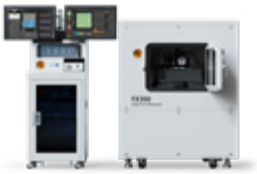
Park FX40

A new class of atomic force microscope: The automatic AFM



Park FX200

The most advanced research AFM for samples from small sizes up to 200 mm



Park FX300

Premier 300 mm AFM for Advanced Research and Reliable Quality Assurance



Park FX200 IR / FX300 IR

AFM-Integrated Nanoscale IR for Precise Chemical and Material Analysis



Park NX10

The most accurate and easiest to use AFM



Park NX20

The most accurate large-sample AFM for failure analysis



Park NX20 300 mm

Premier AFM for accurate 300 mm wafer nanometrology



Park NX12

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Park NX20 Lite

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Park NX-Mask

Advanced AFM for precise mask repair in manufacturing



Park NX-Hybrid WLI

Automated AFM with white light interferometry for semiconductor metrology



Park NX-TSH

Automated AFM for inspecting ultra-large display panel



Park NX-3DM

Automated AFM for high-resolution 3D semiconductor metrology



Park NX-HDM

AFM for media and substrate manufacturing

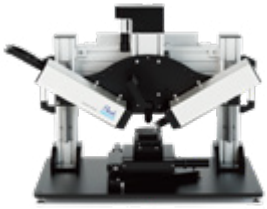
Thin Film Characterization

Imaging ellipsometers combine the benefits of ellipsometry and optical microscopy in a single device. The combination of the two technologies creates a unique metrology tool that redefines the limits of both ellipsometric measurements and polarization-contrast microscopy. The enhanced spatial resolution of imaging ellipsometers expands ellipsometry into new areas of microanalysis, microelectronics, and bio analytics.



Accurion EP4

Imaging ellipsometer for thin film visualization and metrology with high spatial resolution



Accurion SIMON

Entry-level imaging ellipsometer for thin film inspection



Accurion RSE

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Accurion Nano

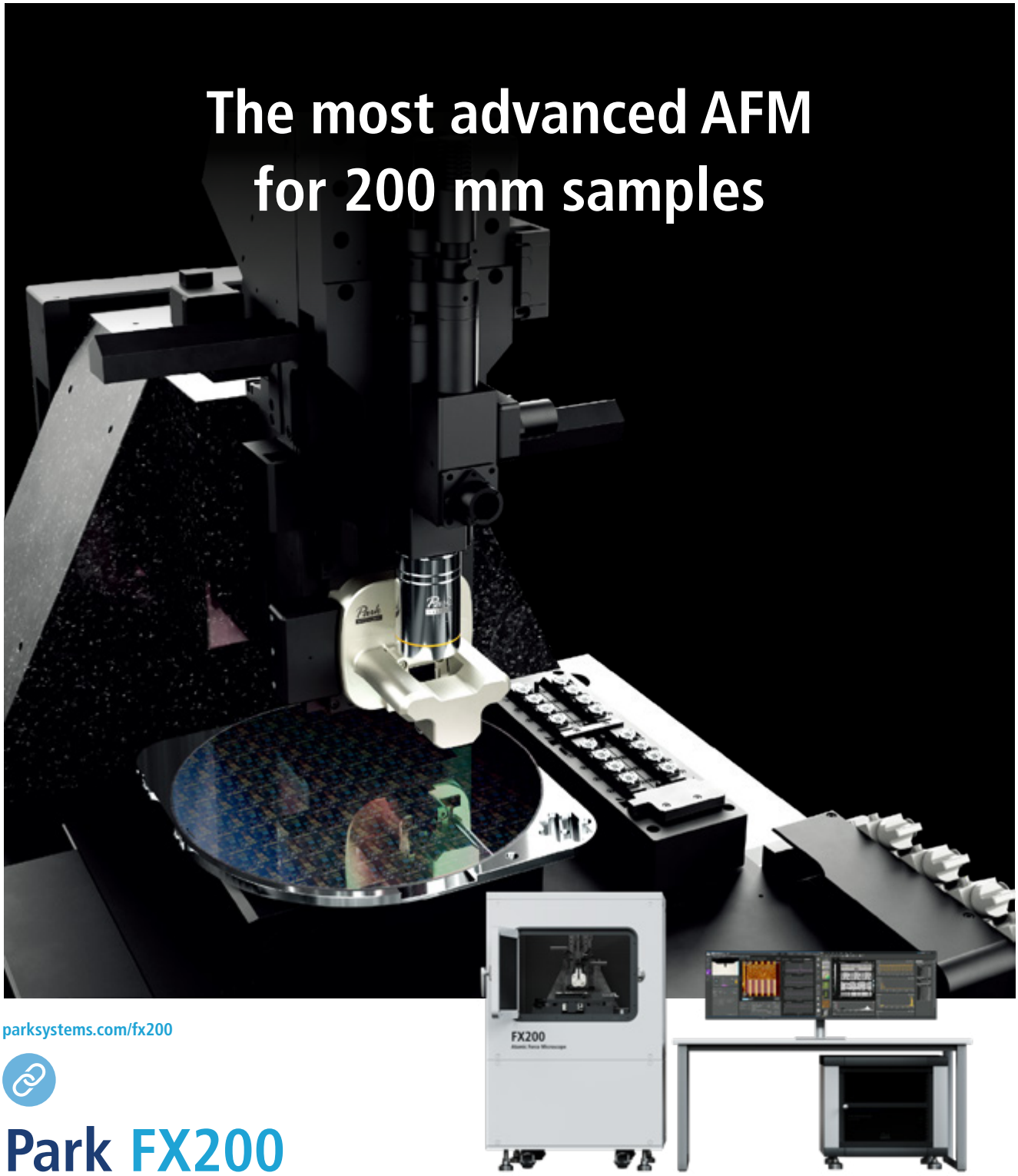
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Auto probe recognition, instant laser alignment, and AI-driven scan optimization.

Achieve Groundbreaking Accuracy
Ultra-low noise, near-zero thermal drift, and rock-solid stability for unmatched precision.

Maximize Throughput Effortlessly
Full-wafer navigation, rapid Z-servo response, and automated multi-point measurements.

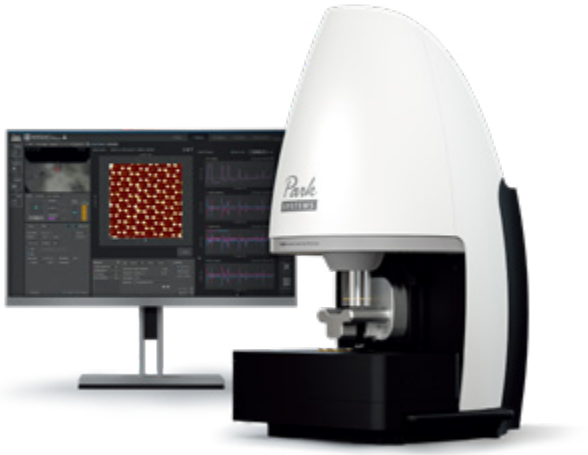
One Nanostep for Microscopy
One Giant Leap for Science



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Park FX40

A New Class of Atomic Force Microscope: The Automatic AFM



The Park FX40 autonomously images and acquires data powered by its artificial intelligence, robotics and machine learning capability. Effortlessly, get the sharpest, clearest, highest resolution images and measurements one sample after another on various applications. Boost your progress and scientific discoveries through unpresedented speed and accuracy.

Enabling Nanoscale Advances

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